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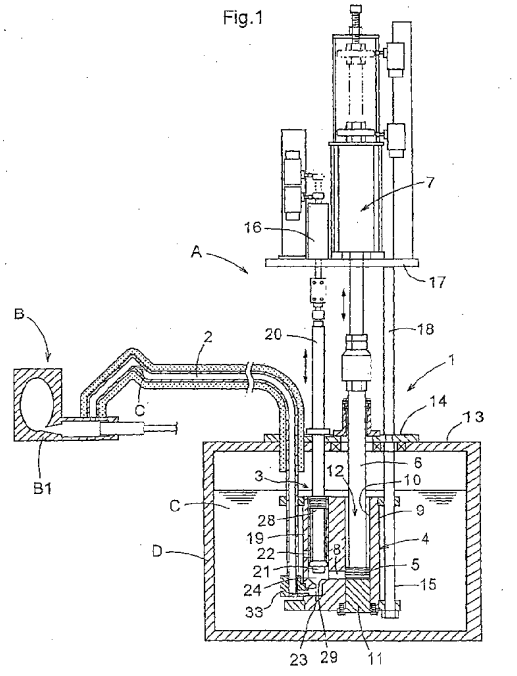
(54) MOLTEN METAL FEEDER

(57) In order to feed molten metal to a casting mold with precision while preventing introduction of metal oxide into a cylinder casing, an entire valve box 19 is disposed below a liquid level of the molten metal C inside a molten metal furnace D. A discharge duct 23 is upwardly open at a lower end of a valve-element moving space 24. An inlet duct 22 is open to the valve-element moving space 24 at a position higher than the discharge duct 23. Around an opening of the discharge duct 23 to the valve-element moving space 24, there is formed a lower receiving seat 29 in the form of a ring. A valve element 21 includes a lower contact portion 31 which comes into annular contact with the lower receiving seat 29 in association with a lowering movement of the valve element 21. The molten metal C inside the molten metal furnace D is introduced into a cylinder casing 4 by moving the valve element 21 to an inlet position where the lower contact portion 31 comes into the annular contact with the lower receiving seat 29 thereby to block communication between the discharge duct 23 and an inlet/outlet duct 8.

Fig.1



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Description

Technical Field

[0001] The present invention relates to a feeding apparatus for molten metal.

[0002] More particularly, the invention relates to a technique of feeding molten meal in which there are provided a molten metal pump capable of introducing molten metal held in a molten metal furnace into a cylinder casing through an inlet/outlet duct by moving a piston mounted within the cylinder casing to one side and capable also of discharging the molten metal in the cylinder casing through the inlet/outlet duct by moving the piston to the other side; a feed duct capable of feeding the molten metal discharged through the inlet/outlet duct to a casting device; and a selector valve having a valve element operable and movable between an inlet position for establishing communication between the inlet/outlet duct and the molten metal furnace while blocking communication between the inlet/outlet duct and the feed duct and an outlet position for establishing communication between the inlet/outlet duct and the feed duct while blocking communication between the inlet/outlet duct and the molten metal furnace, so that with an operation for moving the piston to the one side with the valve element being located at the inlet position, the molten metal in the molten metal furnace is introduced into the cylinder casing whereas with an operation for moving the piston to the other side with the valve element being located at the outlet position, the molten metal in the cylinder casing is discharged to the feed duct.

Background Art

[0003] Next, the conventional technique pertaining to the above-described feeding apparatus for molten metal will be described.

[0004] Fig. 15 shows a conventional molten metal feeding apparatus including a molten metal pump 1 capable of introducing molten metal C held inside a molten metal furnace D through an inlet/outlet duct 8 into a cylinder housing 4 by establishing communication between the inlet/outlet duct 8 and the inside of the cylinder casing 4 and moving upward a piston 5 mounted within the cylinder casing 4 and capable also of discharging the molten metal C held inside the cylinder casing 4 through the inlet/outlet duct 8 by moving downward the piston 5, a driving unit 7 comprising e.g. a pneumatic cylinder for driving and moving the piston 5, a feed duct 2 for feeding the molten metal C discharged through the inlet/outlet duct 8 to a casting mold B1, and a selector valve 3 having a valve box 19 defining, as openings open to a valve-element moving space 24 thereof, an inlet duct 22 communicating with the molten metal furnace D, a discharge duct 23 communicating with a feed duct 2 and the inlet/outlet duct 8 and a valve element 21 mounted therein and vertically movable between an inlet position for establishing communication between the inlet duct 22 and the inlet/outlet duct 8 and blocking communication between the discharge duct 23 and the inlet/outlet duct 8 and an outlet position for establishing communication between the discharge duct 23 and the inlet/outlet duct 8 and blocking communication between the inlet duct 22 and the inlet/outlet duct 8. Then, with an operation on a valve rod 20 by means of a valve-rod operating tool 16 using e.g. a solenoid, as shown in Fig. 15 (a), the valve element 21 is slid to the inlet position. Under this condition, by moving the piston 5 upward, the molten metal C held inside the molten metal furnace D is introduced into the cylinder casing 4. Whereas, as shown in Fig. 15 (b), by moving the piston 5 downward with the valve element 21 being slid and retained at the outlet position, the molten metal C held inside the cylinder casing 4 is discharged to the feed duct 2.

[0005] And, in sliding the valve element 21 within the valve box 19, if high-temperature molten metal highly reactive e.g. oxygen is to be handled, even if there are provided sealants or the like to sliding portions 100 between the valve element 21 and its valve box 19, metal oxide or the like tends to be entrapped between the sliding faces, so that there may develop a situation where the valve element 21 cannot be moved smoothly. Hence, instead of providing such sealant, for the sliding movement of the valve element 21, there is provided a certain amount of clearance between the sliding faces for resisting such entrapment of metal oxide or the like.

[0006] For this reason, when the feeding operation of feeding the molten metal C to the casing mold B1 is effected in repetition, as shown in Fig. 15 (a), when the molten metal C inside the molten metal furnace D is introduced into the cylinder casing 4 by upwardly moving the piston 5 with sliding and retaining the valve element 21 to and at its inlet position, it sometimes happens that an amount of molten metal C remaining in the feed duct 2 may be inadvertently introduced into the cylinder casing 4 via the clearance of the sliding portions 100 or as shown in Fig. 15(b), when the molten metal C held inside the cylinder casing 4 is discharged to the feed duct 2 by downwardly moving the piston 5 with sliding and retaining the valve element 21 to and at its outlet position, the molten metal C inside the cylinder casing 4 may be inadvertently discharged to the side of the molten metal furnace D via the clearance of the sliding portions 100. In such cases, it is not possible to feed to the casing mold B1 the molten metal C by an amount corresponding to the movement stroke of the piston 5, with high precision.

[0007] That is to say, when a plurality of feeding operations are effected in repetition, the next cycle of feeding op-

eration is effected based on the assumption that a portion of the molten metal C discharged by the previous cycle of feeding operation still remains at a predetermined liquid level P within the feed duct 2. Therefore, after an amount of molten metal C corresponding to the movement stroke of the piston 5 has been fed to the casting mold B1, it is required that a portion of the molten metal C discharged by this previous feeding operation remain within the feed duct 2 at the same liquid level P as that of the molten metal C remaining after the previous feeding operation.

[0008] However, at the time of introduction of the molten metal C illustrated in Fig. 15 (a), if a portion of the molten metal C remaining in the feed duct 2 is introduced into the cylinder casing 4 via the clearance between the sliding portions 100 of the valve element 21 and of the valve box 19, this results in the liquid level of the molten metal C remaining in the feed duct 2 becoming lower than the predetermined liquid level P. In such case, in the subsequent feeding operation, even if the molten metal C is discharged to the feed duct 2 by the amount corresponding to the movement stroke of the piston 5, the actual feeding amount to the casting mold B1 will fall short by the amount corresponding to a difference between these liquid levels. Further, at the time of discharge of the molten metal C illustrated in Fig. 15 (b), if a portion of the molten metal C retained within the cylinder casing 4 is discharged to the side of the molten metal furnace D via the clearance of the sliding portions 100, it becomes impossible to discharge the molten metal C to the feed cut 2 by the amount corresponding to the movement stroke of the piston 5, so that there occurs shortage in the amount actually fed to the casting mold B1.

[0009] Moreover, since the entire valve box 19 is disposed below the liquid level of the molten metal C held inside the molten metal furnace D, there is obtained an advantage of restricting the metal oxide which may be entrapped between the sliding faces. However, since the inlet duct 22 is formed at a lower portion of the valve box 19, there is a disadvantage of any metal oxide accumulated at the bottom of the molten metal furnace D tending to be introduced into the cylinder housing 4.

[0010] The present invention has been made in view of the above-described state of the art and its object is to enable high-precision feeding of molten metal to a casting mold by an amount corresponding to a movement stroke of the piston while preventing introduction of metal oxide into the cylinder casing.

[0011] Also, if the inlet opening of the inlet duct is to be open into the molten metal at a high position inside the molten metal furnace so that molten metal with reduced possibility of admixing of metal oxide therein may be introduced into the cylinder casing, it is necessary to separately connect a duct for introduction of molten metal to the inlet duct and to form the entrance of this duct as the inlet opening at a high position inside the molten metal furnace. As a result, there arises a disadvantage of construction complexity.

[0012] And, if the duct for the introduction of molten metal is connected separately to the inlet duct and the entrance of this duct as the inlet opening is provided at a high position inside the molten metal furnace, there arises another disadvantage that when the feeding apparatus is removed out of the molten metal furnace for the purpose of e.g. its maintenance, it is difficult to drain any molten metal remaining within the valve box, the feed duct or the like into the molten metal furnace.

[0013] The present invention has been made in view of the above-described state of the art and its object is to enable a simple construction to allow facilitation of draining of molten metal remaining within the valve box, the feed duct or the like into the molten metal furnace when the feeding apparatus is removed out of the molten metal furnace, while allowing also introduction, into the cylinder casing, of the molten metal with lower possibility of admixture of metal oxide therein.

[0014] Further, the feeding apparatus can be alternatively constructed as follows. Namely, in one such alternative construction, there is provided a selector valve constructed as follows. A valve element as an operated member and its operating rod are coupled together and an insertion hole for allowing vertically movable insertion of the valve element and the operating rod is provided with an upper end thereof being open into the molten metal in the molten metal furnace and with the lower portion of this insertion hole forming a hole for allowing movement of the valve element. Then, the valve element is inserted into the valve element moving hole with the operating rod projecting from the upper end of the insertion hole. Hence, the duct selector valve is capable of switching over the duct for the molten metal by changing its contacting condition relative to the inner face of the valve element moving hole for the valve element in association with a vertical moving operation of the operating rod. In anther alternative construction, there is provided a molten metal pump constructed as follows. A piston as an operated member and its operating rod are connected together and an insertion hole for allowing vertically movable insertion of the piston and the operating rod is provided with an upper end thereof being open into the molten metal in the molten metal furnace and with the lower portion of this insertion hole forming a hole for allowing movement of the piston. Then, the piston is inserted into the piston moving hole with the operating rod projecting from the upper end of the insertion hole. Thus the pump is capable of introducing/discharging the molten metal in and out of the piston moving hole by changing its contacting condition relative to the inner face of the piston moving hole for the piston in association with a vertical moving operation of the operating rod. In such cases, with the above-described duct selector valve or the molten metal pump, the operating rod is inserted into the insertion hole so as to form, between the operating rod and the insertion hole, a continuous clearance along the lower end of the operating rod and the upper end of the insertion hole. Therefore, sludge such as metal oxide

generated adjacent the liquid surface of the molten metal of the molten metal furnace tends to fall along the clearance between the operating rod and the insertion hole and to enter the vicinity of the operated member and get stuck to or accumulated on the inner face of the insertion hole. Hence, there arises a disadvantage that the contact condition of the operated member relative to the inner face of the insertion hole can not be maintained at a desired state for an extended period of time.

[0015] The present invention has been made in view of the above-described state of the art and its object is to enable the contact condition of the operated member relative to the inner face of the insertion hole to be maintained at the desired state for an extended period of time.

Disclosure of the Invention

[0016] According the invention as defined in claim 1, a feeding apparatus for molten metal, comprises: a molten metal pump capable of introducing molten metal held in a molten metal furnace into a cylinder casing through an inlet/outlet duct by communicating the inlet-outlet duct for the molten metal with an inside of the cylinder casing and moving a piston mounted within the cylinder casing to one side and capable also of discharging the molten metal in the cylinder casing through the inlet/outlet duct by moving the piston to the other side; a feed duct for feeding the molten metal discharged through the inlet/outlet duct to a casting mold; and a selector valve having a valve box defining, as openings thereof open to a valve-element moving space thereof, an inlet duct communicating with the molten metal furnace, a discharge duct communicating with the feed duct and the inlet/outlet duct and a valve element mounted therein and vertically movable between an inlet position for establishing communication between the inlet duct and the inlet/outlet duct and blocking communication between the discharge duct and the inlet/outlet duct and an outlet position for establishing communication between the discharge duct and the inlet/outlet duct and blocking communication between the inlet duct and the inlet/outlet duct, so that with an operation for moving the piston to the one side with the valve element being located at the inlet position, the molten metal in the molten metal furnace is introduced into the cylinder casing whereas with an operation for moving the piston to the other side with the valve element being located at the outlet position, the molten metal in the cylinder casing is discharged to the feed duct; the apparatus being characterized in that said entire valve box is disposed below a liquid level of the molten metal inside the molten metal furnace; said discharge duct is upwardly open at a lower end of said valve-element moving space; said inlet duct is open to said valve-element moving space at a position higher than said discharge duct; around an opening of said discharge duct to said valve-element moving space, there is formed a lower receiving seat in the form of a ring; said valve element includes a lower contact portion which comes into annular contact with said lower receiving seat in association with a lowering movement of the valve element; and the molten metal inside the molten metal furnace is introduced into the cylinder casing by moving the valve element to the inlet position where said lower contact portion comes into the annular contact with said lower receiving seat thereby to block communication between the discharge duct and the inlet/outlet duct.

[function and effect]

[0017] Unlike the convention in which the valve element is slid to the inlet position for blocking communication between the discharge duct and the inlet/outlet duct, the valve box forms the discharge duct to be upwardly open at a lower end of the valve-element moving space. And, around this opening, there is formed an annular lower receiving seat and this valve element forms a lower contact portion which comes into annular contact with said lower receiving seat in association with a lowering movement of the valve element; and the molten metal inside the molten metal furnace is introduced into the cylinder casing by moving the valve element to the inlet position where the lower contact portion comes into the annular contact with the lower receiving seat thereby to block communication between the discharge duct and the inlet/outlet duct. With this, it is possible to reliably block the communication between the discharge duct and the inlet/outlet duct. As a result, when the molten metal retained within the molten metal furnace is to be introduced into the cylinder casing, it is possible to effectively prevent the molten metal remaining in the feed duct from being inadvertently introduced to the cylinder casing.

[0018] Further, the entire valve box is disposed below the liquid level of the molten metal held within the molten metal furnace so as to avoid oxidation of the molten metal introduced into the valve box and the discharge duct is upwardly open at the lower end of the valve-element moving space and the inlet duct is open to the valve-element moving space at a position higher than the discharge duct, so as to restrict inadvertent introduction of any metal oxide accumulated at the bottom of the molten metal furnace into the cylinder casing.

[0019] Therefore, when the molten metal held in the molten metal furnace is to be introduced into the cylinder casing, metal oxide accumulated at the bottom of the molten metal furnace will hardly enter the cylinder casing and also since the inadvertent introduction of any molten metal remaining in the feed duct to the cylinder case is effectively restricted, it is possible to feed, with high precision, an amount of molten metal corresponding to the movement stroke of the

piston to the casting mold, while avoiding introduction of metal oxide into the cylinder casing.

[0020] According to the invention as defined in claim 2, said inlet duct is downwardly open at an upper end of said valve-element moving space; around the opening of said inlet duct, there is formed an upper receiving seat in the form of a ring; said valve element includes an upper contact portion which comes into annular contact with said upper receiving seat in association with an upward movement of the valve element; and the molten metal inside the cylinder casing is discharged to the feed duct by moving the valve element to the outlet position where said upper contact portion comes into the annular contact with said upper receiving seat thereby to block communication between the inlet duct and said inlet/outlet duct.

[function and effect]

[0021] Unlike the convention in which the valve element is slid to the outlet position for blocking communication between the inlet duct and the inlet/outlet duct, the valve box forms the inlet duct to be downwardly open at an upper end of the valve-element moving space. And, around this opening, there is formed an annular upper receiving seat and this valve element forms an upper contact portion which comes into annular contact with said upper receiving seat in association with an upward movement of the valve element; and the molten metal inside the cylinder casing is discharged to the feed duct by moving the valve element to the outlet position where the upper contact portion comes into the annular contact with the upper receiving seat thereby to block communication between the inlet duct and the inlet/outlet duct. With this, it is possible to reliably block the communication between the inlet duct and the inlet/outlet duct. As a result, when the molten metal retained within the cylinder casing is to be discharged to the feed duct, it is possible to effectively prevent the molten metal remaining in the cylinder casing from being inadvertently discharged to the side of the molten metal furnace.

[0022] Therefore, when the molten metal held in the cylinder casing is to be discharged to the feed duct, the molten metal held in the cylinder casing will hardly be discharged to the side of the molten metal furnace. As a result, it is possible to feed, with even higher precision, an amount of molten metal corresponding to the movement stroke of the piston.

[0023] According the invention as defined in claim 3, a feeding apparatus for molten metal, comprises: a molten metal pump capable of introducing molten metal held in a molten metal furnace into a cylinder casing through an inlet/outlet duct by communicating the inlet-outlet duct for the molten metal with an inside of the cylinder casing and moving a piston mounted within the cylinder casing to one side and capable also of discharging the molten metal in the cylinder casing through the inlet/outlet duct by moving the piston to the other side; a feed duct for feeding the molten metal discharged through the inlet/outlet duct to a casting device; and a selector valve having a valve box defining, as openings open to a valve-element moving space thereof, an inlet duct communicating with the molten metal furnace, a discharge duct communicating with the feed duct and the inlet/outlet duct and a valve element mounted therein and vertically movable between an inlet position for establishing communication between the inlet duct and the inlet/outlet duct and blocking communication between the discharge duct and the inlet/outlet duct and an outlet position for establishing communication between the discharge duct and the inlet/outlet duct and blocking communication between the inlet duct and the inlet/outlet duct, so that with an operation for moving the piston to the one side with the valve element being located at the inlet position, the molten metal in the molten metal furnace is introduced into the cylinder casing whereas with an operation for moving the piston to the other side with the valve element being located at the outlet position, the molten metal in the cylinder casing is discharged to the feed duct; the apparatus being characterized in that said inlet duct is formed through said valve box to be open to the valve-element moving space at a position higher than said discharge duct; a base member including said cylinder casing forms an engaging portion in which a feed-duct forming member forming said feed duct is removably inserted and engaged from the above; said discharge duct is communicated with the inside of said engaging portion; said discharge duct is communicated with said feed duct with said feed-duct forming member is engaged within said engaging portion; said engaging portion defines, at a bottom thereof, a communicating duct capable of communicating with said molten metal furnace at a position lower than said discharge duct; and said feed-duct forming member integrally includes a covering member capable of closing said communicating duct in association with engagement of said feed-duct forming member within said engaging portion.

[function and effect]

[0024] Since the inlet duct is formed through said valve box to be open to the valve-element moving space at a position higher than said discharge duct, unlike the convention, it is not necessary to connect separately a duct for introducing molten metal to the inlet duct and the inlet opening of the inlet duct may be disposed to be open into the molten metal at a high position within the molten metal furnace.

[0025] And, a base member including said cylinder casing forms an engaging portion in which a feed-duct forming

member forming said feed duct is removably inserted and engaged from the above, said discharge duct is communicated with the inside of said engaging portion and said discharge duct is communicated with said feed duct with said feed-duct forming member is engaged within said engaging portion. Hence, when the feeding apparatus is drawn up out of the molten metal furnace, by pulling up the feed-duct forming member out of the engaging portion, any molten metal present within the feed duct formed in this feed-duct forming member can be discharged into the molten metal furnace. And, with establishment of communication between the inside of the valve box and the inside of the molten metal furnace through the discharge duct, the molten metal present within the valve box can be discharged into the molten metal furnace through the discharge duct.

[0026] Further, said engaging portion defines, at a bottom thereof, a communicating duct capable of communicating with said molten metal furnace at a position lower than said discharge duct; and said feed-duct forming member integrally includes a covering member capable of closing said communicating duct in association with engagement of said feed-duct forming member within said engaging portion. Hence, by pulling up the feed-duct forming member out of the engaging portion, the closure of the communicating duct is released to establish communication between the bottom of the engaging portion with the molten metal furnace via the communicating duct. Thus, when the cylinder case is pulled up out of the molten metal furnace, the risk of any molten metal remaining in the engaging portion is reduced advantageously.

[0027] Therefore, by means of the simple construction wherein the inlet duct is formed though the valve box to be open to the valve-element moving space at a position higher than the discharge duct, molten metal with lower possibility of presence of metal oxide mixed therein can be introduced into the cylinder casing. At the same time, when the feeding apparatus is removed out of the molten metal furnace, any molten metal present within the valve box or the feed duct can be easily discharged into the molten metal furnace.

[0028] According the invention as defined in claim 4, a feeding apparatus for molten metal, comprises: a molten metal pump capable of introducing molten metal held in a molten metal furnace into a cylinder casing through an inlet/outlet duct by communicating the inlet-outlet duct for the molten metal with an inside of the cylinder casing and moving a piston mounted within the cylinder casing to one side and capable also of discharging the molten metal in the cylinder casing through the inlet/outlet duct by moving the piston to the other side; a feed duct for feeding the molten metal discharged through the inlet/outlet duct to a casting device; and a selector valve having a valve box defining, as openings open to a valve-element moving space thereof, an inlet duct communicating with the molten metal furnace, a discharge duct communicating with the feed duct and the inlet/outlet duct and a valve element mounted therein and vertically movable between an inlet position for establishing communication between the inlet duct and the inlet/outlet duct and blocking communication between the discharge duct and the inlet/outlet duct and an outlet position for establishing communication between the discharge duct and the inlet/outlet duct and blocking communication between the inlet duct and the inlet/outlet duct, so that with an operation for moving the piston to the one side with the valve element being located at the inlet position, the molten metal in the molten metal furnace is introduced into the cylinder casing whereas with an operation for moving the piston to the other side with the valve element being located at the outlet position, the molten metal in the cylinder casing is discharged to the feed duct; the apparatus being characterized in that said inlet duct is formed through said valve box to be open to the valve-element moving space at a position higher than said discharge duct; a base member including said cylinder casing forms an engaging portion in which said valve box is removably inserted and engaged from the above; said feed duct is communicated with the inside of said engaging portion; said feed duct is communicated with said discharge duct with said valve box is engaged within said engaging portion; said engaging portion defines, at a bottom thereof, a communicating duct capable of communicating with said molten metal furnace at a position lower than said feed duct; and said valve box integrally includes a covering member capable of closing said communicating duct in association with engagement of said valve box within said engaging portion.

[function and effect]

[0029] Since the inlet duct is formed through said valve box to be open to the valve-element moving space at a position higher than said discharge duct, unlike the convention, it is not necessary to connect separately a duct for introducing molten metal to the inlet duct and the inlet opening of the inlet duct may be disposed to be open into the molten metal at a high position within the molten metal furnace.

[0030] And, a base member including said cylinder casing forms an engaging portion in which the valve box is removably inserted and engaged from the above, said feed duct is communicated with the inside of said engaging portion and said feed duct is communicated with the inner side of the engaging portion, and the feed duct is communicated with said discharge duct when said valve box is engaged within said engaging portion. Hence, when the feeding apparatus is drawn up out of the molten metal furnace, by pulling up the valve box out of the engaging portion, any molten metal present within this valve box can be discharged into the molten metal furnace through the discharge duct. And, with establishment of communication between the feed duct and the inside of the molten metal furnace at the engaging

portion, the molten metal present within the feed duct can be discharged into the molten metal furnace.

[0031] Further, said engaging portion defines therethrough, at a bottom thereof, a communicating duct capable of communicating with said molten metal furnace at a position lower than said feed duct; and said valve box integrally includes a covering member capable of closing said communicating duct in association with engagement of said valve box within said engaging portion. Hence, by pulling up the valve box out of the engaging portion, the closure of the communicating duct is released to establish communication between the bottom of the engaging portion with the molten metal furnace via the communicating duct. Thus, when the cylinder casing is pulled up out of the molten metal furnace, the risk of any molten metal remaining in the engaging portion is reduced advantageously.

[0032] Therefore, by means of the simple construction wherein the inlet duct is formed though the valve box to be open to the valve-element moving space at a position higher than the discharge duct, molten metal with lower possibility of presence of metal oxide mixed therein can be introduced into the cylinder casing. At the same time, when the feeding apparatus is removed out of the molten metal furnace, any molten metal present within the valve box or the feed duct can be easily discharged into the molten metal furnace.

[0033] According to the invention as defined in claim 5, said communicating duct is formed vertically through said feed-duct forming member or said valve box along the inserting/drawing direction; and said covering member comes into engagement with said communicating duct in association with the engagement of said feed-duct forming member or said valve box within said engaging portion.

[function and effect]

[0034] In association with the engaging operation of the feed-duct forming member or the valve box within the engaging portion from the above, the covering member too comes into engagement with the communicating duct thereby to close its opening. Whereas, in association with an upward drawing operation of the feed-duct forming member or the valve box out of the engaging portion, the covering member too becomes disengaged from the communicating duct, thereby to release its closure.

[0035] Therefore, with the simple operation of inserting/drawing the feed-duct forming member or the valve box in one vertical direction, the communicating duct can be closed or its closure can be released easily.

[0036] According to the invention as defined in claim 6, a feeding apparatus for molten metal in which an operated member and its operating rod are coupled together, an insertion hole for allowing vertically movable insertion of the operated member and the operating rod is provided with an upper end thereof being open into the molten metal in a molten metal furnace and said operated member and said operating rod are inserted into said insertion hole so that said operating rod projects from an upper end of said insertion hole, and with a vertically moving operation of said operating rod, said operated member is vertically moved so as to change its contact condition relative to said insertion hole, said apparatus being characterized in that along an outer periphery of said operating rod, there is provided a scraper for closing a gap between said operating rod and said insertion hole, said scraper being slidable along substantially entire periphery of an inner peripheral face of the insertion hole in association with the vertical moving operation of said operating rod.

[function and effect]

[0037] Along an outer periphery of said operating rod, there is provided a scraper for closing a gap between said operating rod and said insertion hole. Hence, it is possible to make it difficult for sludge such as metal oxide generated in the vicinity of the liquid surface of the molten metal in the molten metal furnace to enter the vicinity of the operated member. Further, this scraper is slidable along substantially entire periphery of an inner peripheral face of the insertion hole in association with the vertical moving operation of said operating rod. Hence, even if the sludge gets entrapped between the operating rod and the insertion hole and gets stuck or accumulated thereto, this sludge can be scraped off. As a result, the contact condition of the operated member relative to the inner face of the insertion hole can be maintained as desired for an extended period of time.

[0038] According to the invention as defined in claim 7, when the operated member has moved to the upper end of its movable range, said scraper is moved to the vicinity of the upper end of the insertion hole.

[function and effect]

[0039] When the operated member has moved to the upper end of its movable range, the scraper is moved to the vicinity of the upper end of the insertion hole. Hence, the sludge scraped off by the scraper can be positively returned into the molten metal held in the molten metal furnace. As a result, the contact condition of the operated member relative to the inner face of the insertion hole can be maintained as desired for an extended period of time.

[0040] According to the invention as defined in claim 8, said scraper is formed by non-withdrawably fitting, along the

outer periphery of said operating rod, a ceramic ring member formed like letter C by cutting a peripheral portion thereof and then engaging this ring member within said insertion hole with elastic radially inward deformation of this ring member.

[function and effect]

[0041] A ceramic ring member formed like letter C by cutting a peripheral portion thereof is engaged within said insertion hole with elastic radially inward deformation of this ring member. Hence, the ring member can be in pressed contact with the inner peripheral face of the insertion hole by means of the elastic resilience thereof. As a result, by reducing the gap between the ring member and the inner peripheral face of the insertion hole, intrusion of sludge to the vicinity of the operated member can be prevented in an efficient manner and also the sludge can be scraped off efficiently.

[0042] Further, since the ring member is formed of ceramics, there hardly occurs such phenomenon as "heat-sticking" or "biting" between the ring member and the inner peripheral face of the insertion hole due to mutual sliding therebetween. As a result, with the pressed-contact between the ring member and the inner peripheral face of the insertion hole by means of the elastic resilience of the former, sludge can be scraped off in an efficient manner for an extended period of time.

[0043] According to the invention as defined in claim 9, a lower portion of said insertion hole forms a hole for allowing valve element movement and said operated member comprises a valve element capable of switching over duct for the molten metal by changing its contacting condition relative to the inner face of the valve element moving hole in association with a vertical moving operation of the operating rod.

[function and effect]

[0044] The valve element constituting the operated member is inserted into the valve element moving hole forming the lower portion of the insertion hole, with the operating rod projecting from the upper end of the insertion hole and the duct for the molten metal can be switched over by varying the contact condition thereof relative to the inner peripheral face of the valve-element moving space in association with a vertical moving operation of the operating rod and the scraper is provided along the outer periphery of the operating rod of this valve element. As a result, the contact condition of the valve element relative to the inner face of the valve-element moving hole can be maintained as desired for an extended period of time and the duct for the molten metal can be switched over with high precision.

[0045] According to the invention as defined in claim 10, a lower portion of said insertion hole forms a hole for allowing piston movement and said operated member comprises a piston capable of introducing and discharging the molten metal in and out of the piston moving hole as the piston is vertically slid within the piston moving hole in association with a vertical moving operation of the operating rod.

[function and effect]

[0046] The piston constituting the operated member is inserted into the piston moving hole forming the lower portion of the insertion hole, with the operating rod projecting from the upper end of the insertion hole and the duct for the molten metal can be switched over by varying the contact condition thereof relative to the inner peripheral face of the valve-element moving space in association with a vertical moving operation of the operating rod and the scraper is provided along the outer periphery of the operating rod of this valve element. As a result, the condition in which the contact position of the valve element relative to the inner face of the valve-element moving hole can be varied to a desired contact position, that is, the condition in which the piston can be slid relative to the inner face of the piston moving hole by a desired stroke, can be maintained for an extended period of time and the molten metal can be fed and discharged in and out of the piston moving hole with high precision.

Brief Description of the Drawings

[0047]

Fig. 1 is a side view in partial section of a feeding apparatus for molten metal,
Figs. 2 (a) and (b) are side views in partial section showing principal portions,
Fig. 3 (a) is a perspective view of the principal portions,
Fig. 3 (b) is a vertical section showing the principal portions,
Figs. 4 (a) and (b) are side views in partial sections of principal portions showing a second embodiment,
Figs. 5 (a) and (b) are side views in partial sections of principal portions showing a third embodiment,

Figs. 6 (a) and (b) are side views in partial sections of principal portions showing a fourth embodiment,
Fig. 7 is a section of the principal portions of the fourth embodiment,
Fig. 8 is a perspective view of the principal portions of the fourth embodiment,
Fig. 9 is a section of the principal portions of the fourth embodiment,
Fig. 10 (a) is a perspective view of principal portions showing a sixth embodiment,
Fig. 10 (b) is a section view of the principal portions showing the sixth embodiment,
Fig. 11 is a side view in partial section of principal portions showing a seventh embodiment,
Fig. 12 is a side view in partial section of the principal portions showing the seventh embodiment,
Fig. 13 is a perspective view of principal portions showing an eighth embodiment,
Figs. 14 (a) and (b) are side views in partial section of principal portions showing a ninth embodiment, and
Figs. 15 (a) and (b) are side views in partial sections showing the prior art.

Best Mode of Embodying the Invention

[0048] Next, the present invention will be described by way of embodiments thereof with reference to the accompanying drawings. Incidentally, in the drawings, elements shown with like references denote like elements.

[first embodiment]

[0049] Fig. 1 shows a feeding apparatus A for feeding molten metal C of magnesium alloy as an example of molten metal to a casting mold B1 of a casting device B. The apparatus includes a molten metal pump 1, a feed duct 2 for feeding the molten metal C to the casting mold B1 and a selector valve 3 for switching over ducts between a condition capable of drawing the molten metal C held within a molten metal furnace D into the molten metal pump 1 and a further condition capable of discharging the molten metal C introduced into the molten metal pump 1 to the feed duct 2, so that the apparatus can feed the molten metal C discharged from the molten metal pump 1 to the casting device B1 via the feed duct 2.

[0050] The molten metal pump 1 includes a cylinder casing 4 formed of ceramics (silicon nitride), a piston 5 formed of ceramics (silicon nitride) and vertically movable in reciprocation within the cylinder casing 4 and a piston driving pneumatic cylinder 7 for vertically reciprocating a piston rod 6 formed integrally with the piston 5. In operation, as an inlet/outlet duct 8 for the molten metal C is communicated with a vicinity of the bottom inside the cylinder casing 4 and the piston 5 is moved upward, the molten metal C held within a molten metal furnace D can be introduced via the inlet/outlet duct 8 into the cylinder casing 4 and as the piston 5 is moved downward, the molten metal C held within the cylinder casing 4 can be discharged via the inlet/outlet duct 8.

[0051] Referring to the cylinder casing 4, a cylinder chamber 12 is formed by closing a lower opening of a cylinder-chamber forming through hole 10 defined in a casing body 9 formed of ceramics by means of a cylinder plug 11 formed of ceramics. A base plate 14 secured to a furnace lid13 of the molten metal furnace D is connected with an outer periphery of the casing body 9 by mans of a connecting arm 15 formed of ceramics (silicon nitride), and the cylinder casing 4 is fixed so that this entire cylinder casing 4 may be submerged within the molten metal C at a position lower than a vertically movable range of the liquid level of the molten metal C within the molten metal furnace D. Further, a support table 17 for supporting the piston driving pneumatic cylinder 7 and a valve-operating pneumatic cylinder 16 is secured to the base plate 14 by a mainstay 18.

[0052] Referring to the selector valve 3, as shown also in Fig. 2, the casing body 9 forms a valve box 19 and the entire valve box 19 is disposed downwardly of a liquid level lower than the liquid level vertically movable range of the molten metal C held within the molten metal furnace D. Further, a valve element 21 formed of ceramics (silicon nitride) forming a valve rod 20 integrally therewith is mounted to this valve box 19 to be vertically movable relative thereto. An inlet duct 22 communicating with the molten metal furnace D, a discharge duct 23 communicating with the feed duct 2 and the inlet/outlet duct 8 are formed to be open to a valve-element moving space 24.

[0053] Referring to the valve-element moving space 24, as shown in Fig. 2, a cylindrical valve-element attaching hole 25 into and from which the valve element 21 can be inserted and withdrawn is formed in the casing body 9 and a sleeve 26 is fitted and fixed within an upper inner peripheral face of this valve-element attaching hole 25 and forming a valve-element attaching hole portion lower than the sleeve 26.

[0054] The discharge duct 23 is formed to be upwardly open at the lower end of the valve-element moving space 24 and an inlet through hole 27 extending from the casing body 9 and the sleeve 26 is formed. The inlet duct 22 downwardly open at the upper end of the valve-element moving space 24 located at a higher position than the discharge duct 23 is formed by the inlet through hole 27 and the inner side of the sleeve 26 and the inlet opening of the inlet duct 22 is open to the molten metal C held within the molten metal furnace D. Further, the valve rod 20 includes a covering member 28 slidable relative to the inner face of the sleeve 26 so as to close the gap between the valve rod 20 and the sleeve 26.

[0055] The discharge duct 23 is formed in a discharge-duct forming member (an example of base member) 33 formed of ceramics (silicon nitride) and bolt-fixed to the casing body 9 and is open to the bottom of the valve-element moving space 24. To this discharge-duct forming member 33, a cylindrical feed pipe (an example of a feed-duct forming member) 34 formed of ceramics (silicon nitride) is connected to communicate the feed duct 2 to the discharge duct 23.

[0056] Around the opening of the discharge duct 23 to the valve-element moving space 24, there is formed an annular upwardly oriented lower receiving seat 29. And, around the opening of the inlet duct 22 to the valve-element moving space 24, that is, at the bottom face of the sleeve 26, there is formed an annular downwardly oriented upper receiving seat 30. Whereas, the valve element 21 includes a lower contact portion 31 which comes into annular contact with the lower receiving seat 29 in association with a lowering movement of the valve element 21 and an upper contact portion 32 which comes into annular contact with the upper receiving seat 30 in association with an upward movement of the valve element 21.

[0057] In operation, with an expanding or contacting operation of the valve-operating pneumatic cylinder 16, the valve element 21 is vertically movable between an inlet position in which the upper contact portion 32 departs from the upper receiving seat 30 to establish communication between the inlet duct 22 and the inlet/outlet duct 23 and also the lower contact portion 31 comes into the annular contact with the lower receiving seat 29 thereby to block communication between the discharge duct 23 and the inlet/outlet duct 8 as shown in Fig. 2 (a) and an outlet position in which the lower contact portion 31 departs from the lower receiving seat 29 thereby to establish communication between the discharge duct 23 and the inlet/outlet duct 8 and also the upper contact portion 32 comes into the annular contact with the upper receiving seat 30 thereby to block communication between the inlet duct 22 and the inlet/outlet duct 8 as shown in Fig. 2 (b). Then, as shown in Fig. 2 (a), by operating the piston 5 upward with the valve element 21 being shifted to the inlet position, the molten metal C held within the molten metal furnace D is drawn into the cylinder casing 4 via the inlet duct 22 and the inlet/outlet duct 8. Whereas, as shown in Fig. 2 (b), by operating the piston 5 downward with the valve element 21 being shifted to the outlet position, the molten metal C held within the cylinder casing 4 is discharged to the feed duct 2 via the inlet/outlet duct 8 and the discharge duct 23 to the feed duct 2 so that the molten metal can be fed to the casting mold B1.

[0058] As shown in Fig. 3, the discharge-duct forming member 33 forms an engaging hole (an example of engaging portion) 36 having a circular shape in its plan view into which a feed pipe 34 is removable inserted from the above and fixed in position to establish communication between the discharge duct 33 with the inside of the engaging hole 36 and this engaging hole 36 is formed vertically through the feed pipe 34 along its inserting/withdrawing direction. At the bottom of this engaging portion 36, there is formed a communicating duct 37 capable of communicating with the molten metal furnace D at a position lower than the discharge duct 23.

[0059] The feed pipe 34 integrally forms a pipe-end closing member 38 formed of ceramics (silicon nitride) for closing the bottom end of this pipe and a through hole 39 is formed in a pipe wall adjacent the pipe-end closing member 38. So that, as the feed pipe 34 is fitted within the engaging hole 36, the discharge duct 23 is communicated with the feed duct 2.

[0060] And, a feed-pipe lower end portion 40 is formed integrally with the feed pipe 34 so as to act as a closing member capable of engaging with the communicating duct 37 and closing the same in association with the engagement of the feed pipe 34 within the engaging hole 36 thereby to close this communicating duct 37.

[second embodiment]

[0061] Fig. 4 shows principal portions of a feeding apparatus A according to a further embodiment. In this, a feed pipe 34 is connected to a feed-duct forming member 44 communicating with the discharge duct 23 and a valve rod 20 includes a valve-element portion 41 which is vertically slidable relative to the inner face of the sleeve 26. The valve element 21 is vertically movable between an inlet position in which the valve element portion 41 is drawn out of the sleeve 26 thereby to establish communication between the inlet duct 22 and the inlet/outlet duct 8 and also the lower contact portion 31 comes into the annular contact with the lower receiving seat 29 thereby to block communication between the discharge duct 23 and the inlet/outlet duct 8 as shown in Fig. 4 (a) and an outlet position in which the lower contact portion 31 departs from the lower receiving seat 29 thereby to establish communication between the discharge duct 23 and the inlet/outlet duct 8 and also the valve element portion 41 becomes engaged within the sleeve 26 thereby to block communication between the inlet duct 22 and the inlet/outlet duct 8 as shown in Fig. 4 (b).

[0062] The rest of this construction is identical to that of the first embodiment.

[third embodiment]

[0063] Fig. 5 shows a feeding apparatus A according to a further embodiment for feeding the molten metal C of magnesium alloy as an example of molten metal to the casting device B. Next, those portions of this embodiment different from the first embodiment will be explained.

[0064] As shown in Fig. 5, a feed pipe 34 is connected to a feed-duct forming member 44 communicating with the discharge duct 23. A selector valve 3 is provided to be inserted into and removed out of the casing body 9 from the above. The valve box 19 including the discharge duct 23 communicating with the feed duct 2 and the inlet-outlet duct 8 as openings at the lower portion of the valve-element moving space 24 defines therethrough the inlet duct 22 communicating with the molten metal furnace D at the upper portion of the valve-element moving space 24 which portion is located at a higher position than the discharge duct 23.

[0065] And, a base member 42 extending continuously from the lower portion of the casing body 9 forms a circular engaging hole (an example of engaging portion) 43 within which the valve box 19 is removably inserted from the above and fixed in position and an intermediate portion of the inlet/outlet duct 8 is communicated with the inside of the engaging hole 43. Further, a feed-duct forming member 44 formed of ceramics (silicon nitride) is bolt-fixed to the base member 42 and the feed duct 2 is communicated with the inside of the engaging hole 43. As the valve box 19 is engaged within the engaging hole 43 and fixed in position therein, the inlet/outlet duct 8 is communicated with the cylinder chamber 12 and the valve-element moving space 24 and also the feed duct 2 is communicated with the discharge duct 23.

[0066] At the bottom of the engaging hole 43, there is formed a communicating duct 45 capable of communicating with the molten metal furnace D at a position lower than the feed duct 2 is formed vertically through the valve box 19 along the inserting/withdrawing direction. And, the valve box 19 forms, as a projection at the lower end thereof, a closing member 46 engageable with the communicating duct 45 for closing this duct 45 in association with the engagement of the valve box 19 within the engaging hole 43.

[0067] The rest of the construction is identical to that of the first embodiment.

[fourth embodiment]

[0068] Fig. 6 shows a further embodiment of a molten metal pump 1 and a selector valve 3 which are provided in a feeding apparatus A for feeding to a casting device B molten metal C such as magnesium alloy, aluminum alloy, zinc alloy etc. as an example of molten metal. And, to a piston 5 of this molten metal pump 1, there is attached a piston ring 74 as a sealing ring E according to the present invention. Further, a valve rod 20 of the selector valve 3 is provided with a scraper 71 according to the present invention.

[0069] The piston ring 74, as shown in Fig. 8, comprises a heat-resistant member 81 having a quadrilateral cross section formed by sintering of silicon nitride material and in the C shape by cutting a portion thereof in the peripheral direction so as to be radially elastically deformable. As shown also in Fig. 6, between the inner peripheral face of the cylinder casing 4 and the outer peripheral face of the piston 5, which are faces opposed to each other in a direction normal to the moving direction of the cylinder casing 4 and the piston 5 as a pair of members movable relative to each other in one direction, the piston ring is elastically deformed in the radially contracting direction so that its peripheral face is pressed by its elastic resilience against the inner peripheral face of the cylinder casing (one of the members) 4 and also is fitted within an annular groove 5a defined in the outer periphery of the piston 5, thereby to prevent relative movement relative to the piston (the other member) 5 in the reciprocating direction. Whereby, in association with a reciprocating movement of the piston 5, the peripheral face is slid relative to the inner peripheral face of the cylinder casing 4, thereby to prevent displacement of the molten metal C through the gap between the opposed faces.

[0070] And, a thickness size T of the heat-resistant member 81 along the ring diameter direction is set to be greater than 0.02 times and less than 0.2 times of the ring outer diameter K. Further, a width size H of the heat-resistant member 81 along the ring axis direction X is set to be greater than 0.2 times and less than 1.5 times of the thickness size T. With these, sufficient strength and sufficient elastic deformation amount in the radial direction are assured. As a result, even when the piston 5 is moved together with the piston ring 74 against heat-sticking force of the piston ring 74 relative to the cylinder casing 4, breakage of the piston ring 74 hardly occurs. Further, as shown in Fig. 9, even when an abnormal condition develops that the piston 5 is reciprocated along the cylinder axis Z with the piston axis Y being inclined relative to the cylinder axis Z, thereby to result in increase in the clearance between the outer peripheral face of the piston 5 and the inner peripheral face of the cylinder casing 4, the sufficient sealing effect can be assured and also sludge can be scraped off sufficiently.

[0071] Referring now to the selector valve 3, the spool-type valve element (an example of an operated member) 21 and its valve rod (an example of an operating rod) 20 are formed together of ceramic (silicon nitride) and connected substantially coaxial to each other. Further, an inserting hole 62 into which the valve element 21 and the valve rod 20 are inserted to be vertically movable therein is formed in the casing body 9 so that its upper end may be open at a position below a liquid level lower than the liquid level movable range of the molten metal C held within the molten metal furnace D. And, the valve element 21 and the valve rod 20 are inserted into the insertion hole 62 so that the valve rod 20 may project upwardly from the upper end of the insertion hole 62.

[0072] The insertion hole 62 is formed such that an upper large-diameter insertion hole 63 and a lower small-diameter insertion hole 64 are connected via a tapered hole portion 65 whose diameter varies with tapering. The lower end of the small-diameter insertion hole 64 is closed by a valve plug 66. The small-diameter insertion hole 64 forms a hole

for allowing valve-element movement. A molten metal inlet duct 22 is formed laterally to communicate with the inside of the molten metal furnace D in the vicinity of the lower end of the valve-element moving hole 64. A molten metal discharge duct 23 communicating with the feed pipe 34 and the inlet/outlet duct 8 are formed one above the other to be open to the valve-element moving hole 64. And, a communicating duct 67 is formed laterally to establish communication between the inside of the molten metal furnace D and the large-diameter insertion hole 63.

[0073] The valve element 21, like the piston ring 74 shown in Fig. 8, includes a pair of upper and lower valve-element portions 69, 70 including a sealing ring 68 formed of ceramics (silicon nitride) having C shape and in slidable contact to an inner peripheral face of the valve-element moving hole 64. In operation, with a vertically moving operation of the valve rod 20 by activation of the valve-operating pneumatic cylinder 16, the valve element 21 is vertically moved within the valve-element moving hole 64 so as to switch over the duct for the molten metal C by varying the contact condition relative to the inner face of the valve-element moving hole between a condition (to be referred to as "inlet position" hereinafter) to establish communication between the inlet duct 22 and the inlet/outlet duct 8 and also to block communication between the discharge duct 23 and the inlet/outlet duct 8 by the lower valve-element portion 70 as shown in Fig. 6 (a) and a further condition (to be referred to as "outlet position" hereinafter) to establish communication between the discharge duct 23 and the inlet/outlet duct 8 and also to block communication between the discharge duct 23 and the large-diameter insertion hole 63 by means of the upper valve-element portion 69 and also to block communication between the inlet duct 22 and the inlet/outlet duct 8 by means of the lower valve-element portion 70 as shown in Fig. 6 (b).

[0074] And, as shown in Fig. 6 (a), as the piston 5 is moved upward with the valve element 21 being shifted to the inlet position, the molten metal C held within the molten metal furnace D is drawn into the cylinder chamber 12. Whereas, as shown in Fig. 6 (b), as the piston 5 is moved downward with the valve element 21 being shifted to the outlet position, the molten metal C held within the cylinder chamber 12 is discharged to the feed duct 2 of the feed pipe 34.

[0075] Around the outer periphery of the valve rod 20, there is provided a scraper 71 which closes the gap between this valve rod 20 and the large-diameter insertion hole 63 and which is slidable along the substantially entire periphery relative to the inner peripheral face of the large-diameter insertion hole in association with a vertically moving operation of the valve rod 20, with the scraper 71 being provided such that it is moved to the vicinity of the upper end of the large-diameter insertion hole 63 when the valve element 21 is shifted to the upper end of the vertically movable range thereof.

[0076] The scraper 71, as shown in Fig. 7, includes a ring member 72 formed of ceramics (silicon nitride) which is non-removably fitted in an annular groove 20a defined in the outer periphery of the valve rod 20, thereby to prevent intrusion of sludge such as metal oxide generated in the vicinity of the liquid surface of the molten metal in the molten metal furnace D to the vicinity of the valve element 21. Further, even when sludge becomes adhered to the inner peripheral face of the large-diameter insertion hole, this sludge can be scraped off by a vertical sliding movement of the ring member 72 relative to the inner peripheral face of the large-diameter insertion hole in association with the operation of the valve element 21.

[0077] The ring member 72, like the piston ring 74 shown in Fig. 8, is radially elastically deformable by cutting a peripheral portion of the ring by a substantially constant width into the shape of C. And, this ring member 72 is elastically deformed in the radially inward direction (diameter reducing direction) to be fitted in the large-diameter insertion hole 63, so that the ring is pressed and contacted by means of its own elastic resilience, against the inner peripheral face of the large-diameter insertion hole.

[0078] Incidentally, since cut end faces 73 of the ring member 72 are formed each with an inclination along the peripheral direction so as to be relatively movable along the peripheral direction with these end faces 73 being opposed to each other in the sliding direction, it is possible to effectively prevent introduction of the sludge together with the molten metal C through the cut portion of the ring member 72 to the side of the valve element 21.

[0079] Incidentally, in the foregoing embodiment, the cylinder casing 4, the piston 5, the piston rod 6, the piston ring 74, the connecting arm 15, the valve element 21, the valve rod 20, the sealing ring 68 and the ring member 72 are formed of silicon nitride. However, when the molten metal C comprises molten metal of magnesium alloy, a steel type material such as SKD may be used. Further, a surface treatment such as an aluminizing treatment may be effected on these components if appropriate.

[0080] The rest of the construction is identical to the first embodiment.

[fifth embodiment]

[0081] Though not shown, in place of the piston ring 74 shown in the seventh embodiment which comprises the heat-resistant member 81 formed of silicon nitride, it is possible to provide a piston ring 74 comprising a heat-resistant member 81 formed by sintering a composite material of a metal material such as titanium (Ti) or the like and a ceramic material such as titanium carbide (TiC).

[0082] The rest of the construction is identical to the fourth embodiment.

[sixth embodiment]

[0083] Fig. 10 shows a further embodiment of the piston ring 74 as the sealing ring E. In this case, the heat-resistant member 81 has a cross sectional shape which is provided as a trapezoid having two sides 81a, 81b extending parallel with each other along the ring axis X direction. And, as shown in Fig. 10 (b), the longer side 81b of the two sides 81a, 81b parallel with each other is engaged into a dovetail groove 5b formed like a ring in the outer peripheral portion of the piston (the other member) 5 and a peripheral face of the shorter side 81a of the two sides 81a, 81b parallel with each other is placed in pressed contact against the cylinder casing (one member) 4.

[0084] The rest of the construction is identical to that of the fourth or the fifth embodiment.

[seventh embodiment]

[0085] Fig 11 shows another example of the molten metal pump 1 shown in the fourth embodiment. In this case, the cylinder casing 4 includes a cylindrical casing body 9 formed of ceramics (silicon nitride) having a lower opening 82 open into the molten metal C held within the molten metal furnace D and a circular casing top plate 83 formed of ceramics (silicon nitride) for closing the top opening of the casing body 9. And, inside the casing body 9 between the piston 5 formed of ceramics (silicon nitride) having the piston ring 74 like that shown in the seventh embodiment and the casing top plate 83, there is formed a cylinder chamber 12 and an inlet/outlet duct 8 communicating with the cylinder chamber 12 is formed.

[0086] At the upper end of the casing body 9, there is integrally formed a cylindrical spacer 84 and this cylindrical spacer 84 is secured to a furnace lid 13 of the molten metal furnace D. And, the cylinder casing 4 is secured so that this entire cylinder casing 4 may be submerged in the molten metal C at a position lower than a lowermost liquid level L of the liquid level movable range of the molten metal C within the molten metal furnace D.

[0087] To the top of the cylindrical spacer 84, there is fixed a cylindrical member 85 formed of ceramics (silicon nitride) operable to press the casing top place 83 against the casing body 9 from the above. Further, a bearing member 87 formed of ceramics (silicon nitride) having a bearing cylindrical portion 86 for vertically movably supporting the piston rod 6 is fixed so as to close the inside of the cylindrical member 85. And, the piston rod 6 is inserted through the bearing cylindrical portion 86 and an insertion hole 88 defined in the casing top plate 83, with the piston rod 6 being vertically movable back and forth. In operation, as the piston 8 is reciprocated by a vertical reciprocating operation of the piston rod 6, the molten metal C drawn into the cylinder chamber 12 via the inlet/outlet duct 8 can be discharged via the inlet/outlet duct 8 into the feed pipe 34 to be fed eventually to the casting device B.

[0088] And, as shown also in Fig. 12, between the opposing faces of the piston rod 6 and the casing top plate 83 in the direction normal to the moving direction provided as a pair of members which can reciprocate relative to each other in one direction, a sealing ring E according to the present invention is radially elastically deformed and fitted within an annular groove 89 defined in the inner periphery of the through hole 88 so that its peripheral face is pressed and contacted by the elastic resilience thereof against the piston rod (one member) 6 and its relative movement relative to the casing top plate (the other member) 83 in the reciprocating direction is prevented. In operation, in association with a reciprocating movement of the piston rod 6 relative to the casing top plate 83, the peripheral face is slid relative to the piston rod 6, thereby to prevent displacement of the molten metal C via the gap between the opposing faces. As a result, it is possible to prevent introduction of the molten metal C via the gap between the opposing faces when the molten metal C is to be drawn into the cylinder chamber 12 and also to prevent leakage of the molten metal C via the gap between the opposing faces when the molten metal C drawn into the cylinder chamber 12 is to be fed to the casing device B. Moreover, sludge of the molten metal C stuck to or accumulated on the peripheral face of the piston rod 6 may be scraped away by the sealing ring E, thereby to avoid the trouble of the sealing ring E becoming heat-stuck to the piston rod 6 via such sludge.

[0089] The rest of the construction is identical that of any one of the fourth through sixth embodiments.

[0090] Sealing rings (to be referred to as Samples 1-13 hereinafter) having differing dimensions of different combinations of the ring outer diameter K of the sealing ring E, the thickness T of the heat-resistant member 81 along the ring radial direction and the width H of the same along the ring axial direction were made and these rings were fitted respectively as the piston rings 74 to the piston 5 of the molten metal pump 1 described in the seventh embodiment. And, the pump was continuously operated with each sample and the running time period until each of Samples 1-13 became damaged or heat-stuck to the cylinder casing 4 was measured.

[0091] [Table 1] shows the results of this study. As shown, with Samples 8 and 9 in which the ratio (T/K) of the thickness T relative to the ring outer diameter K is not greater than 0.02, the samples were broken after about one month running time period. And, with Sample 11 in which the ratio (T/K) of the thickness T relative to the ring outer diameter K exceeds 0.2, the piston rod 6 was deformed after about one month running time period and became heat-stuck to the cylinder casing 4.

[0092] Further, of Samples 1-7, Sample 10 and Samples 12, 13 in which the ratio (T/K) of the thickness T relative

to the ring outer diameter K is greater than 0.02 and less than 0.2, in the case of Samples 10 and 12 in which the ratio (H/T) of the width H relative to the thickness T is not greater than 0.2, heat-sticking to the cylinder casing 4 occurred after about one month running time period. With Sample 13 in which the ratio (H/T) of the width H relative to the thickness T exceeds 1.5, it was broken after about one month running time period. On the other hand, of those samples in which the ratio (T/K) of the thickness T relative to the ring outer diameter K is greater than 0.02 and less than 1.5, in the case of Samples 1-7 in which the ratio (H/T) of the width H relative to the thickness T is greater than 0.2 and less than 1.5, they exhibited good result with no damage or no heat-sticking even after more than 6 months of running time period. Hence, it was found that with these good durability and sealing performance can be readily secured.

[0093] Incidentally, the mark SN shown in the column of material denotes ceramics formed by sintering of silicon nitride having hardness of 90 HRA and density of 3.2. The further mark MC denotes metal ceramics formed by sintering of composite material of titanium (Ti) and titanium carbide (TiC).

Table 1

Sample	ring outer diameter K (mm)	thickness T (mm)	width H (mm)	T/K	H/T	material	running time
Sample 1	45	5.0	6	0.11	0.83	SN	more than 6 months
Sample 2	80	5.0	8	0.063	0.63	SN	more than 6 months
Sample 3	45	1.5	5	0.03	0.30	MC	more than 6 months
Sample 4	80	2.5	10	0.031	0.25	MC	more than 6 months
Sample 5	50	8.5	42	0.17	0.20	SN	more than 6 months
Sample 6	50	2.5	2.5	0.05	1.0	SN	more than 6 months
Sample 7	45	4.5	3	0.10	1.5	SN	more than 6 months
Sample 8	50	1.0	5	0.018	0.20	SN	broken after 1 month
Sample 9	80	1.5	10	0.019	0.15	MC	broken after 1 month
Sample 10	45	4.0	50	0.09	0.08	SN	heat-stuck after 1 month
Sample 11	45	9.9	8	0.22	1.24	SN	stuck due to deformation of piston rod
Sample 12	80	2.5	128	0.031	0.019	SN	stuck after 1 month
Sample 13	80	4.0	2.5	0.05	1.6	SN	broken after 1 month

[eighth embodiment]

[0094] Fig,. 13 shows a further embodiment of the ring member 72. In this, each cut end face 73 is formed like a hook having a peripheral-direction end face portion 73a having a long extension along the peripheral direction and a sliding-direction end face portion 73b having a long extension along the sliding direction and formed at opposed ends of the peripheral-direction end face portion 73a. In operation, with radial elastic deformation, the peripheral-direction end face portions 73a opposed to each other in the sliding direction slide and move along the peripheral direction. As a result, it is possible to effectively prevent the sludge together with the molten metal C from moving via the cut portion

of the ring member 72 to the side of the valve element 21 or the piston 5.

[ninth embodiment]

[0095] Fig. 14 shows principal portions of a further embodiment of a feeding apparatus A for feeding molten metal C to the casting device B. In this, the insertion hole 62 into which the valve element (an example of the operated member) 21 and the valve rod (an example of the operating rod) 20 of the selector valve 3 are inserted comprises an upper small-diameter insertion hole 90 and a lower large-diameter insertion hole 91 which are connected via a tapered hole portion like that of the seventh embodiment. So that, the valve-element moving hole is formed by the portion extending from a vertically intermediate portion of the small-diameter insertion hole 90 to the large-diameter insertion hole 91. And, a molten-metal discharge duct 23 communicating with the feed pipe 34 is open to the bottom of the large-diameter insertion hole 91 and the inlet/outlet duct 8 is open at a vertically intermediate portion of the large-diameter insertion hole 91, and, a molten-metal inlet duct 22 is formed laterally to establish communication between the inside of the molten metal furnace D and the small-diameter insertion hole 90.

[0096] The valve element 21 includes a lower sliding valve-element portion 92 in which a C-shaped ceramic sealing ring 63 is disposed to come into sliding contact with the inner peripheral face of the small-diameter insertion hole 90 and a contact valve-element portion 93 which comes into contact with a valve seat 94 formed at the bottom of the large-diameter insertion 91. In operation, as the valve element 21 is vertically moved by a vertically moving operation of the valve rod 20 with activation of the valve operating pneumatic cylinder 16, the duct for the molten metal C can be switched over by changing the contact condition relative to the inner face of the valve-element moving hole between a condition (to be referred to as "inlet position" hereinafter) for establishing communication between the inlet duct 22 and the inlet/outlet duct 8 and also blocking communication between the discharge duct 23 and the inlet/outlet duct 8 by the contact valve-element portion 93 as shown in Fig. 14 (a) and a further condition (to be referred to as "outlet position" hereinafter) for establishing communication between the discharge duct 23 and the inlet/outlet duct 8 and also blocking communication between the inlet duct 22 and the inlet/outlet duct 8 by means of the lower sliding valve-element portion 92 as shown in Fig. 14 (b).

[0097] And, at an upper portion of the lower sliding valve-element portion 92, there is provided an upper sliding valve-element portion 95. A sealing ring 68 slidable along substantially entire periphery of the inner peripheral face of the small-diameter insertion hole in association with a vertically moving operation of the valve rod 20 is provided to move to the vicinity of the upper end of the small-diameter insertion hole 90 when the valve element 21 is shifted to the upper end of its vertically movable range.

[0098] Further, referring to the molten metal pump 1, a piston (an example of the operated member) 5 fitted with a piston ring 74 formed of ceramics (silicon nitride) and its piston rod (an example of the operating rod) 6 are formed together of ceramics (silicon nitride) and connected substantially coaxially. Further, a cylinder-chamber forming through hole (an example of the insertion hole)10 into which the piston 5 and the piston rod 6 are inserted to be vertically movable therein is formed with a substantially constant inner diameter in the casing body 9 so that its upper end may be open below a liquid level lower than the liquid level movable range of the molten metal C held within the molten metal furnace D. The piston 5 and the piston rod 6 are inserted into the cylinder-chamber forming through hole 10 so that the piston rod 6 may project upwardly from the upper end of the cylinder-chamber forming through hole 10.

[0099] Referring to the cylinder-chamber forming through hole 10, its lower end is closed by the cylinder plug 11 and the lower portion of this cylinder-chamber forming through hole 10 forms a piston moving hole. Hence, the piston rod 5 is vertically slid by a vertically moving operation of the piston rod 6 associated with activation of the piston driving pneumatic cylinder 7. As shown in Fig. 14 (a), as the piston 5 is moved upward with the valve element 21 being shifted to the inlet position, the molten metal C held within the molten metal furnace D is drawn into the piston moving hole. Whereas, as shown in Fig. 14 (b), as the piston 5 is moved downward with the valve element 21 being shifted to the outlet position, the molten metal C held within the piston moving hole is discharged to the feed pipe 34.

[0100] The piston rod 6 includes a small-diameter rod 75 connected to the piston driving pneumatic cylinder 7 and a large-diameter rod 76 formed as an upper extension of the piston 5. On the outer periphery of the large-diameter rod 76, there is attached a scraper 71 for closing the gap between the large-diameter rod 76 and the cylinder-chamber forming through hole 10 and being slidable along substantially entire periphery of the inner peripheral face of the cylinder-chamber forming through hole in association with a vertically moving operation of the piston rod 6, the scraper 71 being moved to the vicinity of the upper end of the cylinder-chamber forming through hole 10 when the piston 5 is shifted to the upper end of its vertically movable range.

[0101] Referring to the scraper 71, like the one disclosed in the fourth embodiment, a ring member 72 formed of ceramics (silicon nitride) formed as a C-shaped member by cutting one peripheral portion is non-removably attached on the outer periphery of the large-diameter rod 76 and this ring member 72 is elastically deformed to the radially inward side to be fitted within the cylinder-chamber forming through hole 10 and pressed against the inner peripheral face of the cylinder-chamber forming through hole.

[0102] The rest of the construction is identical to the first embodiment.

[other embodiments]

[0103]

1. The invention's feeding apparatus for molten metal can be used also for feeding molten metal of aluminum, zinc, tin, etc. to a casting mold.

2. In the invention's feeding apparatus for molten metal, at the bottom of the engaging portion, a communicating duct capable of communicating with the molten metal furnace can be laterally formed therethrough.

3. The invention's feeding apparatus for molten metal can be used also for feeding the molten metal to a ladle provided in the casting device.

4. The invention's feeding apparatus for molten metal can be used also for feeding molten metal of aluminum, zinc, tin, etc.

5. In the invention's feeding apparatus for molten metal, the scraper may include a metal ring member formed of e.g. titanium (Ti) non-removably attached on the outer periphery of the operating rod, with this ring member being elastically deformed to the radially inward side to be fitted within the insertion hole.

6. In the invention's feeding apparatus for molten metal, the operated member comprises a valve element which is vertically moved within the valve-element moving hole by a vertically moving operation of the valve rod as the operating rod whereby the duct is switched over only by its contact with a valve seat formed in the inner face of the valve-element moving hole.

7. In the invention's feeding apparatus for molten metal, the piston rod acting as the operating rod may be formed with a smaller diameter than the outer diameter of the piston acting as the operated member.

Industrial Applicability

[0104] The invention relates to a feeding apparatus for molten metal and is useful for improvement of precision of molten metal feeding operation and maintenance.

Claims

1. A feeding apparatus for molten metal, comprising: a molten metal pump capable of introducing molten metal held in a molten metal furnace into a cylinder casing through an inlet/outlet duct by communicating the inlet-outlet duct for the molten metal with an inside of the cylinder casing and moving a piston mounted within the cylinder casing to one side and capable also of discharging the molten metal in the cylinder casing through the inlet/outlet duct by moving the piston to the other side; a feed duct for feeding the molten metal discharged through the inlet/outlet duct to a casting mold; and a selector valve having a valve box defining, as openings thereof open to a valve-element moving space thereof, an inlet duct communicating with the molten metal furnace, a discharge duct communicating with the feed duct and the inlet/outlet duct and a valve element mounted therein and vertically movable between an inlet position for establishing communication between the inlet duct and the inlet/outlet duct and blocking communication between the discharge duct and the inlet/outlet duct and an outlet position for establishing communication between the discharge duct and the inlet/outlet duct and blocking communication between the inlet duct and the inlet/outlet duct, so that with an operation for moving the piston to the one side with the valve element being located at the inlet position, the molten metal in the molten metal furnace is introduced into the cylinder casing whereas with an operation for moving the piston to the other side with the valve element being located at the outlet position, the molten metal in the cylinder casing is discharged to the feed duct;

characterized in that

said entire valve box is disposed below a liquid level of the molten metal inside the molten metal furnace; said discharge duct is upwardly open at a lower end of said valve-element moving space; said inlet duct is open to said valve-element moving space at a position higher than said discharge duct; around an opening of said discharge duct to said valve-element moving space, there is formed a lower receiving seat in the form of a ring;

said valve element includes a lower contact portion which comes into annular contact with said lower receiving seat in association with a lowering movement of the valve element; and the molten metal inside the molten metal furnace is introduced into the cylinder casing by moving the valve element to the inlet position where said lower contact portion comes into the annular contact with said lower receiving seat thereby to block communication between the discharge duct and the inlet/outlet duct.

2. The molten metal feeding apparatus as defined in claim 1, **characterized in that** said inlet duct is downwardly open at an upper end of said valve-element moving space; around the opening of said inlet duct, there is formed an upper receiving seat in the form of a ring; said valve element includes an upper contact portion which comes into annular contact with said upper receiving seat in association with an upward movement of the valve element; and the molten metal inside the cylinder casing is discharged to the feed duct by moving the valve element to the outlet position where said upper contact portion comes into the annular contact with said upper receiving seat thereby to block communication between the inlet duct and said inlet/outlet duct.

3. A feeding apparatus for molten metal comprising: a molten metal pump capable of introducing molten metal held in a molten metal furnace into a cylinder casing through an inlet/outlet duct by communicating the inlet-outlet duct for the molten metal with an inside of the cylinder casing and moving a piston mounted within the cylinder casing to one side and capable also of discharging the molten metal in the cylinder casing through the inlet/outlet duct by moving the piston to the other side; a feed duct for feeding the molten metal discharged through the inlet/outlet duct to a casting device; and a selector valve having a valve box defining, as openings open to a valve-element moving space thereof, an inlet duct communicating with the molten metal furnace, a discharge duct communicating with the feed duct and the inlet/outlet duct and a valve element mounted therein and vertically movable between an inlet position for establishing communication between the inlet duct and the inlet/outlet duct and blocking communication between the discharge duct and the inlet/outlet duct and an outlet position for establishing communication between the discharge duct and the inlet/outlet duct and blocking communication between the inlet duct and the inlet/outlet duct, so that with an operation for moving the piston to the one side with the valve element being located at the inlet position, the molten metal in the molten metal furnace is introduced into the cylinder casing whereas with an operation for moving the piston to the other side with the valve element being located at the outlet position, the molten metal in the cylinder casing is discharged to the feed duct;

characterized in that

said inlet duct is formed through said valve box to be open to the valve-element moving space at a position higher than said discharge duct; a base member including said cylinder casing forms an engaging portion in which a feed-duct forming member forming said feed duct is removably inserted and engaged from the above; said discharge duct is communicated with the inside of said engaging portion; said discharge duct is communicated with said feed duct with said feed-duct forming member is engaged within said engaging portion; said engaging portion defines, at a bottom thereof, a communicating duct capable of communicating with said molten metal furnace at a position lower than said discharge duct; and said feed-duct forming member integrally includes a covering member capable of closing said communicating duct in association with engagement of said feed-duct forming member within said engaging portion.

4. A feeding apparatus for molten metal, comprising: a molten metal pump capable of introducing molten metal held in a molten metal furnace into a cylinder casing through an inlet/outlet duct by communicating the inlet-outlet duct for the molten metal with an inside of the cylinder casing and moving a piston mounted within the cylinder casing to one side and capable also of discharging the molten metal in the cylinder casing through the inlet/outlet duct by moving the piston to the other side; a feed duct for feeding the molten metal discharged through the inlet/outlet duct to a casting device; and a selector valve having a valve box defining, as openings open to a valve-element moving space thereof, an inlet duct communicating with the molten metal furnace, a discharge duct communicating with the feed duct and the inlet/outlet duct and a valve element mounted therein and vertically movable between an inlet position for establishing communication between the inlet duct and the inlet/outlet duct and blocking communication between the discharge duct and the inlet/outlet duct and an outlet position for establishing communication between the discharge duct and the inlet/outlet duct and blocking communication between the inlet duct and the inlet/outlet duct, so that with an operation for moving the piston to the one side with the valve element being located at the inlet position, the molten metal in the molten metal furnace is introduced into the cylinder casing whereas with an operation for moving the piston to the other side with the valve element being located at the outlet position, the molten metal in the cylinder casing is discharged to the feed duct;

characterized in that

said inlet duct is formed through said valve box to be open to the valve-element moving space at a position higher than said discharge duct; a base member including said cylinder casing forms an engaging portion in which

said valve box is removably inserted and engaged from the above; said feed duct is communicated with the inside of said engaging portion; said feed duct is communicated with said discharge duct with said valve box is engaged within said engaging portion; said engaging portion defines, at a bottom thereof, a communicating duct capable of communicating with said molten metal furnace at a position lower than said feed duct; and said valve box integrally includes a covering member capable of closing said communicating duct in association with engagement of said valve box within said engaging portion.

5. The molten metal feeding apparatus as defined in claim 4, **characterized in that** said communicating duct is formed vertically along the inserting/drawing direction of said feed-duct forming member or said valve box; and said covering member comes into engagement with said communicating duct in association with the engagement of said feed-duct forming member or said valve box within said engaging portion.

6. A feeding apparatus for molten metal in which an operated member and its operating rod are coupled together, an insertion hole for allowing vertically movable insertion of the operated member and the operating rod is provided with an upper end thereof being open into the molten metal in a molten metal furnace and said operated member and said operating rod are inserted into said insertion hole so that said operating rod projects from an upper end of said insertion hole, and with a vertically moving operation of said operating rod, said operated member is vertically moved so as to change its contact condition relative to said insertion hole;

characterized in that

along an outer periphery of said operating rod, there is provided a scraper for closing a gap between said operating rod and said insertion hole, said scraper being slidable along substantially entire periphery of an inner peripheral face of the insertion hole in association with the vertical moving operation of said operating rod.

7. The molten metal feeding apparatus as defined in claim 6, **characterized in that** when the operated member has moved to the upper end of its movable range, said scraper is moved to the vicinity of the upper end of the insertion hole.

8. The molten metal feeding apparatus as defined in claim 6 or 7, **characterized in that** said scraper is formed by non-withdrawably fitting, along the outer periphery of said operating rod, a ceramic ring member formed like letter C by cutting a peripheral portion thereof and then engaging this ring member within said insertion hole with elastic radially inward deformation of this ring member.

9. The molten metal feeding apparatus as defined in ay one of claims 6-8, **characterized in that** a lower portion of said insertion hole forms a hole for allowing valve element movement and said operated member comprises a valve element capable of switching over duct for the molten metal by changing its contacting condition relative to the inner face of the valve element moving hole in association with a vertical moving operation of the operating rod.

10. The molten metal feeding apparatus as defined in any one of claims 6-8, **characterized in that** a lower portion of said insertion hole forms a hole for allowing piston movement and said operated member comprises a piston capable of introducing and discharging the molten metal in and out of the piston moving hole as the piston is vertically slid within the piston moving hole in association with a vertical moving operation of the operating rod.

Amended claims under Art .19.1 PCT

1. A feeding apparatus for molten metal, comprising: a molten metal pump capable of introducing molten metal held in a molten metal furnace into a cylinder casing through an inlet/outlet duct by communicating the inlet-outlet duct for the molten metal with an inside of the cylinder casing and moving a piston mounted within the cylinder casing to one side and capable also of discharging the molten metal in the cylinder casing through the inlet/outlet duct by moving the piston to the other side; a feed duct for feeding the molten metal discharged through the inlet/outlet duct to a casting system; and a selector valve having a valve box defining, as openings thereof open to a valve-element moving space thereof, an inlet duct communicating with the molten metal furnace, a discharge duct communicating with the feed duct and the inlet/outlet duct and a valve element mounted therein and vertically movable between an inlet position for establishing communication between the inlet duct and the inlet/outlet duct and blocking communication between the discharge duct and the inlet/outlet duct and an outlet position for establishing communication between the discharge duct and the inlet/outlet duct and blocking communication between the inlet duct and the inlet/outlet duct, so that with an operation for moving the piston to the one side with the valve element being located at the inlet position, the molten metal in the molten metal furnace is introduced into the

cylinder casing whereas with an operation for moving the piston to the other side with the valve element being located at the outlet position, the molten metal in the cylinder casing is discharged to the feed duct;

characterized in that

said discharge duct is upwardly open at a lower end of said valve-element moving space; said inlet duct is open to said valve-element moving space at a position higher than said discharge duct; around an opening of said discharge duct to said valve-element moving space, there is formed a lower receiving seat in the form of a ring; said valve element includes a lower contact portion which comes into annular contact with said lower receiving seat in association with a lowering movement of the valve element; and the molten metal inside the molten metal furnace is introduced into the cylinder casing by moving the valve element to the inlet position where said lower contact portion comes into the annular contact with said lower receiving seat thereby to block communication between the discharge duct and the inlet/outlet duct;

said valve box forms a cylindrical valve-element attaching hole capable of removably introducing the valve element therein; at an upper inner peripheral face of said valve-element attaching hole, a removable sleeve is fitted and fixed thereto; said inlet duct is formed at an upper portion of the valve-element moving space, said molten metal inside said cylinder casing is discharged to the feed duct by moving said valve element to an outlet position where the element comes into contact or sliding contact with said sleeve thereby to block communication between said inlet duct and said inlet/outlet duct.

2. The molten metal feeding apparatus as defined in claim 1, **characterized in that** with an upward movement of said valve member, said valve member comes into engagement within said sleeve, thereby to block the communication between said inlet duct and said inlet/outlet duct.

3. The molten metal feeding apparatus as defined in claim 1, **characterized in that** an upper receiving seat is formed at a lower end of said sleeve and said valve element includes an upper contact portion which comes into annular contact with said upper receiving seat in association with an upward movement of said valve element.

4. A feeding apparatus for molten metal, comprising: a molten metal pump capable of introducing molten metal held in a molten metal furnace into a cylinder casing through an inlet/outlet duct by communicating the inlet-outlet duct for the molten metal with an inside of the cylinder casing and moving a piston mounted within the cylinder casing to one side and capable also of discharging the molten metal in the cylinder casing through the inlet/outlet duct by moving the piston to the other side; a feed duct for feeding the molten metal discharged through the inlet/outlet duct to a casting system; and a selector valve having a valve box defining, as openings open to a valve-element moving space thereof, an inlet duct communicating with the molten metal furnace, a discharge duct communicating with the feed duct and the inlet/outlet duct and a valve element mounted therein and vertically movable between an inlet position for establishing communication between the inlet duct and the inlet/outlet duct and blocking communication between the discharge duct and the inlet/outlet duct and an outlet position for establishing communication between the discharge duct and the inlet/outlet duct and blocking communication between the inlet duct and the inlet/outlet duct, so that with an operation for moving the piston to the one side with the valve element being located at the inlet position, the molten metal in the molten metal furnace is introduced into the cylinder casing whereas with an operation for moving the piston to the other side with the valve element being located at the outlet position, the molten metal in the cylinder casing is discharged to the feed duct;

characterized in that

said inlet duct is formed through said valve box to be open to the valve-element moving space at a position higher than said discharge duct; a base member including said cylinder casing forms an engaging portion in which a feed-duct forming member forming said feed duct is removably inserted and engaged from the above; said discharge duct is communicated with the inside of said engaging portion; said discharge duct is communicated with said feed duct with said feed-duct forming member is engaged within said engaging portion; said engaging portion defines, at a bottom thereof, a communicating duct capable of communicating with said molten metal furnace at a position lower than said discharge duct; and said feed-duct forming member integrally includes a covering member capable of closing said communicating duct in association with engagement of said feed-duct forming member within said engaging portion.

5. (amended) The molten metal feeding apparatus as defined in claim 4, **characterized in that** said communicating duct is formed vertically along the inserting/withdrawing direction of the feed-duct forming member, and said covering member comes into engagement with the communicating duct in association with the engagement of the feed-duct forming member within the engaging portion.

6. (amended) A feeding apparatus for molten metal, comprising: a molten metal pump capable of introducing

molten metal held in a molten metal furnace into a cylinder casing through an inlet/outlet duct by communicating the inlet-outlet duct for the molten metal with an inside of the cylinder casing and moving a piston mounted within the cylinder casing to one side and capable also of discharging the molten metal in the cylinder casing through the inlet/outlet duct by moving the piston to the other side; a feed duct for feeding the molten metal discharged through the inlet/outlet duct to a casting system; and a selector valve having a valve box defining, as openings open to a valve-element moving space thereof, an inlet duct communicating with the molten metal furnace, a discharge duct communicating with the feed duct and the inlet/outlet duct and a valve element mounted therein and vertically movable between an inlet position for establishing communication between the inlet duct and the inlet/outlet duct and blocking communication between the discharge duct and the inlet/outlet duct and an outlet position for establishing communication between the discharge duct and the inlet/outlet duct and blocking communication between the inlet duct and the inlet/outlet duct, so that with an operation for moving the piston to the one side with the valve element being located at the inlet position, the molten metal in the molten metal furnace is introduced into the cylinder casing whereas with an operation for moving the piston to the other side with the valve element being located at the outlet position, the molten metal in the cylinder casing is discharged to the feed duct;

characterized in that

said inlet duct is formed through said valve box to be open to the valve-element moving space at a position higher than said discharge duct; a base member including said cylinder casing forms an engaging portion in which said valve box is removably inserted and engaged from the above; said feed duct is communicated with the inside of said engaging portion; said feed duct is communicated with said discharge duct with said valve box is engaged within said engaging portion; said engaging portion defines, at a bottom thereof, a communicating duct capable of communicating with said molten metal furnace at a position lower than said feed duct; and said valve box integrally includes a covering member capable of closing said communicating duct in association with engagement of said valve box within said engaging portion.

7. (amended) The molten metal feeding apparatus as defined in claim 6, **characterized in that** said communicating duct is formed vertically along the inserting/drawing direction of said valve box; and said covering member comes into engagement with said communicating duct in association with the engagement of said valve box within said engaging portion.

8. (amended) A feeding apparatus for molten metal, comprises: a molten metal pump capable of introducing molten metal held in a molten metal furnace into a cylinder casing through an inlet/outlet duct by communicating the inlet-outlet duct for the molten metal with an inside of the cylinder casing and moving a piston mounted within the cylinder casing to one side and capable also of discharging the molten metal in the cylinder casing through the inlet/outlet duct by moving the piston to the other side; a feed duct for feeding the molten metal discharged through the inlet/outlet duct to a casting system; and a selector valve having a valve box defining, as openings open to a valve-element moving space thereof, an inlet duct communicating with the molten metal furnace, a discharge duct communicating with the feed duct and the inlet/outlet duct and a valve element mounted therein and vertically movable between an inlet position for establishing communication between the inlet duct and the inlet/outlet duct and blocking communication between the discharge duct and the inlet/outlet duct and an outlet position for establishing communication between the discharge duct and the inlet/outlet duct and blocking communication between the inlet duct and the inlet/outlet duct, so that with an operation for moving the piston to the one side with the valve element being located at the inlet position, the molten metal in the molten metal furnace is introduced into the cylinder casing whereas with an operation for moving the piston to the other side with the valve element being located at the outlet position, the molten metal in the cylinder casing is discharged to the feed duct;

characterized in that

said molten metal pump includes a cylinder-chamber forming hole formed in said cylinder casing, a piston vertically movable within said cylinder-chamber forming hole, and an operating rod for vertically moving said piston; and said operating rod includes, upwardly of said piston, a scraper for closing a gap between said operating rod and said cylinder-chamber forming hole and slidable along substantially entire periphery relative to said cylinder-chamber forming hole in association with the vertical moving operation of said operating rod.

9. (amended) A feeding apparatus for molten metal, comprises: a molten metal pump capable of introducing molten metal held in a molten metal furnace into a cylinder casing through an inlet/outlet duct by communicating the inlet-outlet duct for the molten metal with an inside of the cylinder casing and moving a piston mounted within the cylinder casing to one side and capable also of discharging the molten metal in the cylinder casing through the inlet/outlet duct by moving the piston to the other side; a feed duct for feeding the molten metal discharged through the inlet/outlet duct to a casting system; and a selector valve having a valve box defining, as openings open to a valve-

element moving space thereof, an inlet duct communicating with the molten metal furnace, a discharge duct communicating with the feed duct and the inlet/outlet duct and a valve element mounted therein and vertically movable between an inlet position for establishing communication between the inlet duct and the inlet/outlet duct and blocking communication between the discharge duct and the inlet/outlet duct and an outlet position for establishing communication between the discharge duct and the inlet/outlet duct and blocking communication between the inlet duct and the inlet/outlet duct, so that with an operation for moving the piston to the one side with the valve element being located at the inlet position, the molten metal in the molten metal furnace is introduced into the cylinder casing whereas with an operation for moving the piston to the other side with the valve element being located at the outlet position, the molten metal in the cylinder casing is discharged to the feed duct;

characterized in that

said valve box includes an insertion hole having an upper end open to the molten metal in the molten metal furnace; said selector valve includes an operating rod capable of vertically moving operation; said valve element includes a valve-element portion disposed to come into sliding contact with an inner peripheral face of said insertion hole; in association with a vertical movement of said valve element within said insertion hole by said operating rod, the duct for the molten metal can be switched over between an inlet position for establishing communication between said inlet duct and said inlet/outlet duct and blocking communication between said discharge duct and said inlet/outlet duct by means of said valve-element portion and an outlet position for establishing communication between said discharge duct and said inlet/outlet duct and blocking communication between said discharge duct and said insertion hole by means of said valve-element portion and blocking also communication between said inlet duct and said inlet/outlet duct by means of said valve-element portion; and

the operating rod includes, upwardly of said valve-element portion, a scraper for closing a gap between this operating rod and said insertion hole and slidable along substantially entire periphery relative to the inner peripheral face of the insertion hole in association with the vertical moving operation of said operating rod.

10. (amended) The molten metal feeding apparatus as defined in claim 9, **characterized in that** said insertion hole comprises an upper large-diameter insertion hole and a lower small-diameter insertion hole connected together, the valve element includes a pair of upper and lower valve-element portions provided to come into sliding contact with an inner peripheral face of the small-diameter insertion hole, and with a vertical movement of the valve element within the insertion hole by the operating rod, the duct for the molten metal is switched over between an inlet position for establishing communication between the inlet duct and the inlet/outlet duct and blocking communication between the discharge duct and the inlet/outlet duct by means of the lower valve-element portion and an outlet position for establishing communication between the discharge duct and the inlet/outlet duct and blocking communication between the discharge duct and the insertion hole by means of the upper valve-element portion and blocking also communication between the inlet duct and the inlet/outlet duct by means of the lower valve-element portion.

11. (amended) The molten metal feeding apparatus as defined in any one of claims 8-10, **characterized in that** when the operating rod has moved to the upper end of its movable range, said scraper is moved to the vicinity of the upper end of the insertion hole.

12. (new) The molten metal feeding apparatus as defined in any one of claims 8-10, **characterized in that** said scraper is formed by non-withdrawably fitting, along the outer periphery of said operating rod, a ceramic ring member formed like letter C by cutting a peripheral portion thereof and then engaging this ring member within said insertion hole with elastic radially inward deformation of this ring member.

Fig.1

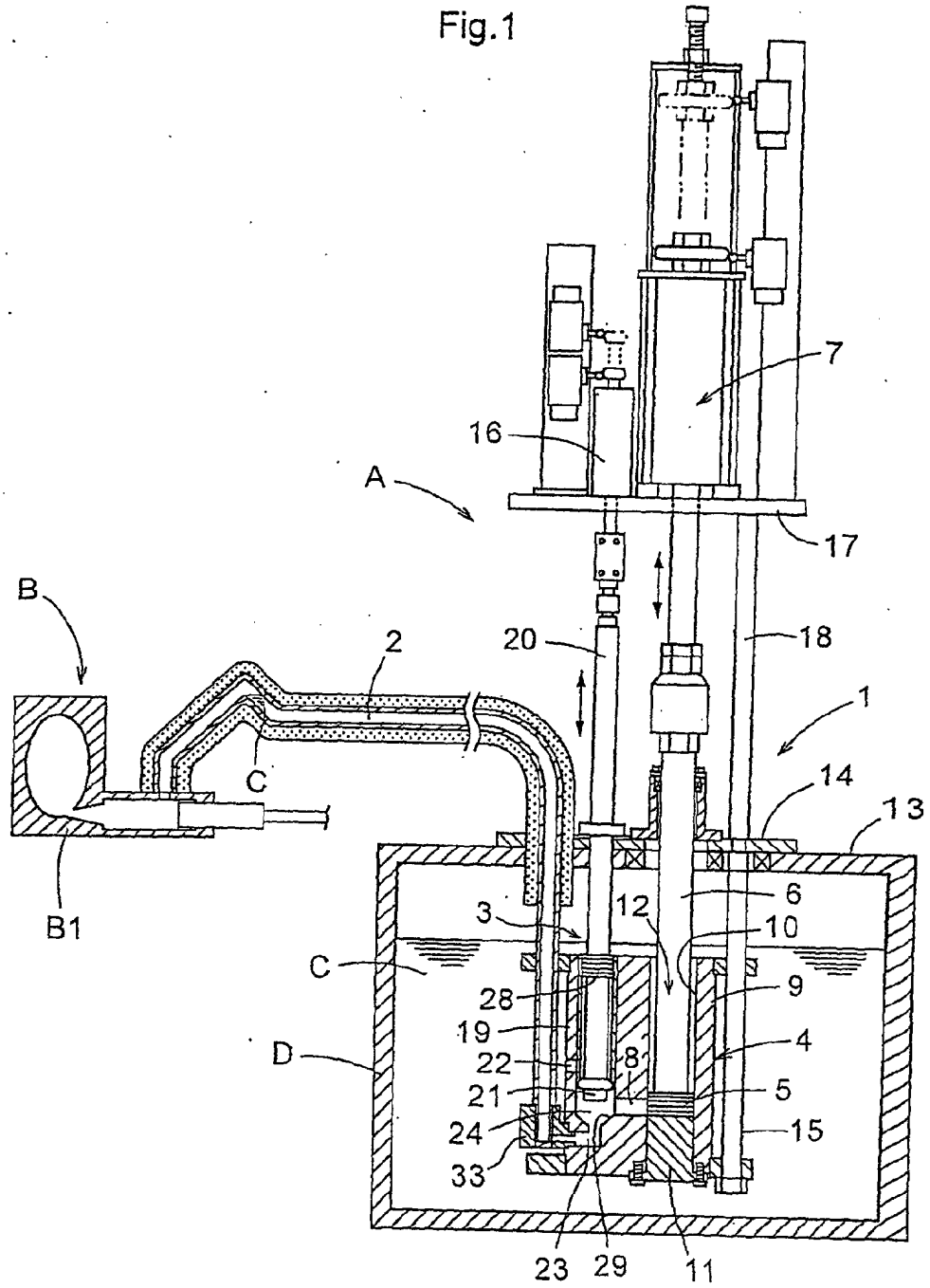
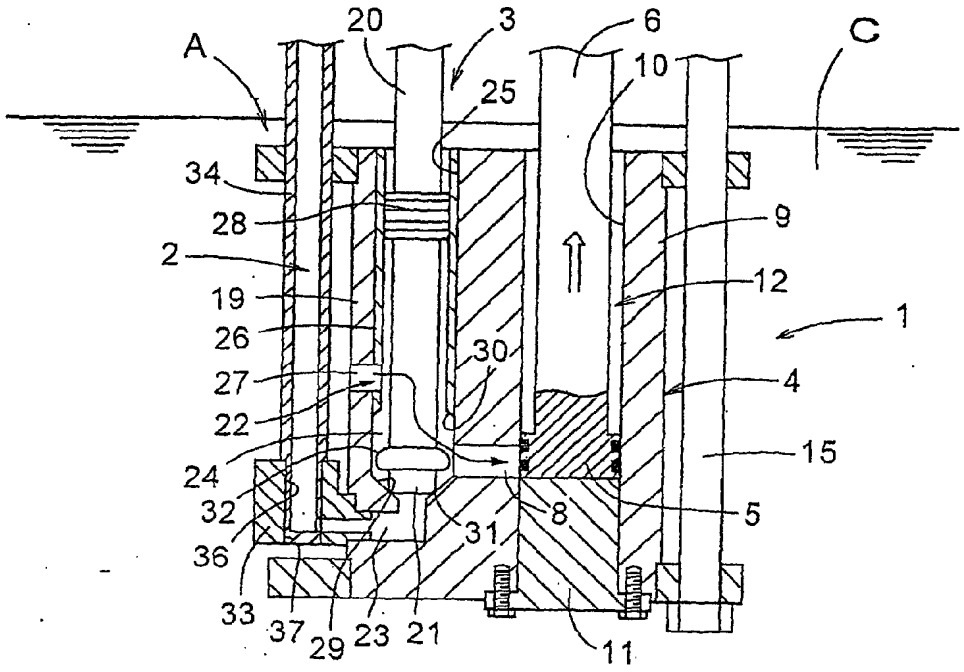

7
16
A
17
B
20
18
2
1
C
14
13
B1
6
3
12
10
C
9
28
19
4
D
22
8
21
5
24
15
33
23
29
11

Fig.2

(a)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C
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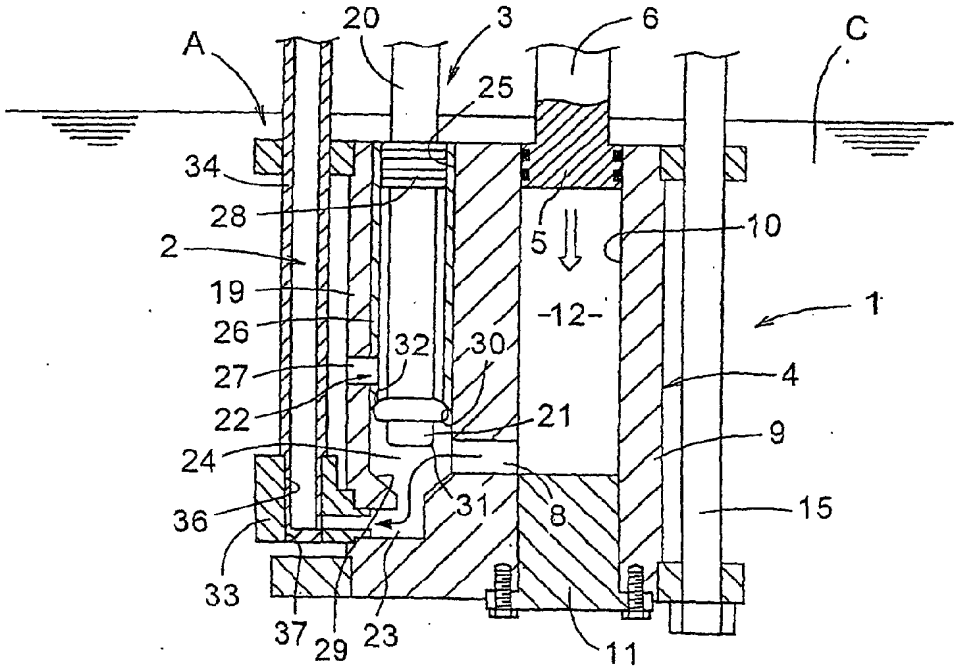
11

(b)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20
3
6
C
25
34
28
5
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2
19
1
-12-
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9
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15
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37
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23
11

Fig.3

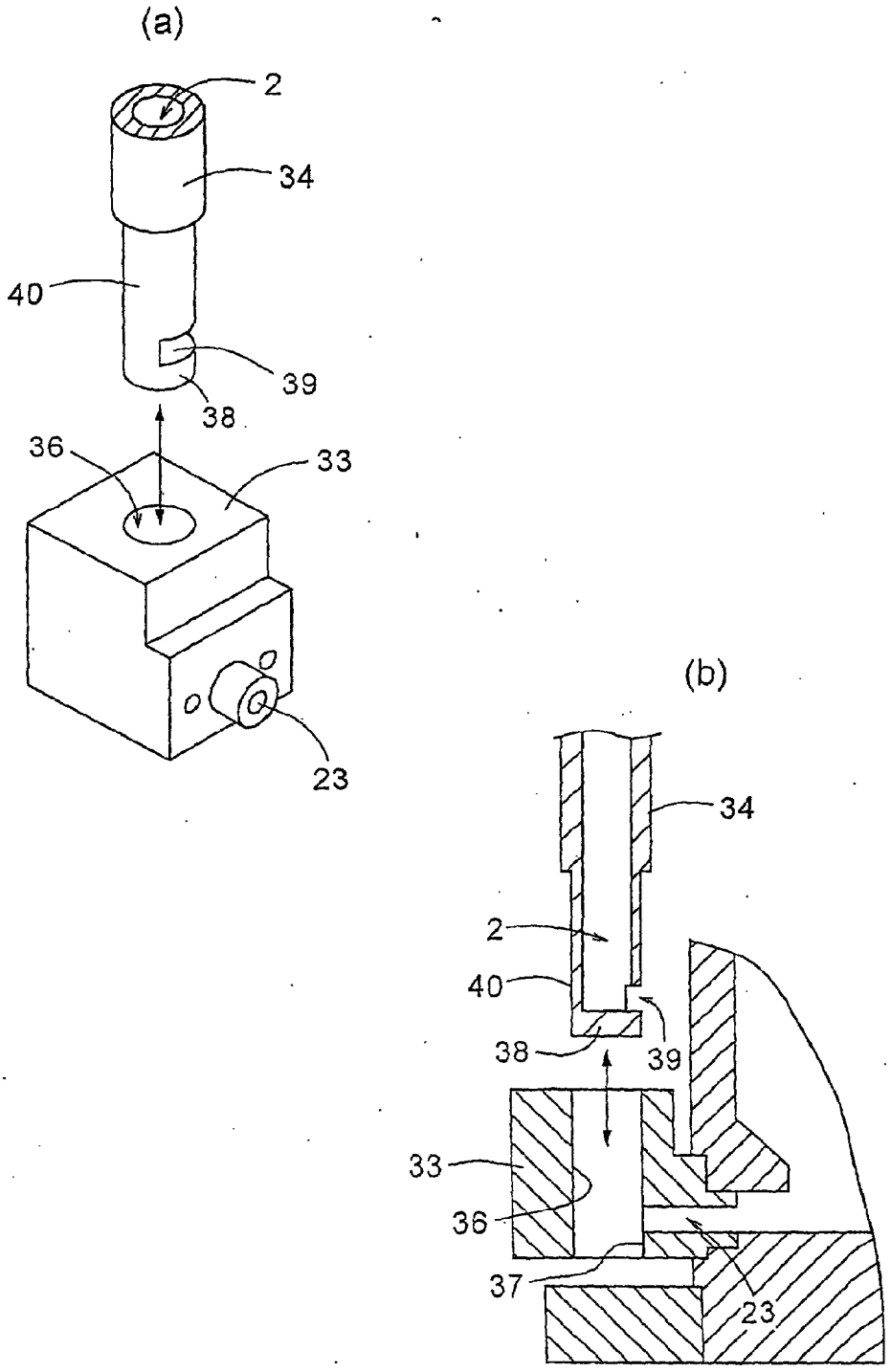
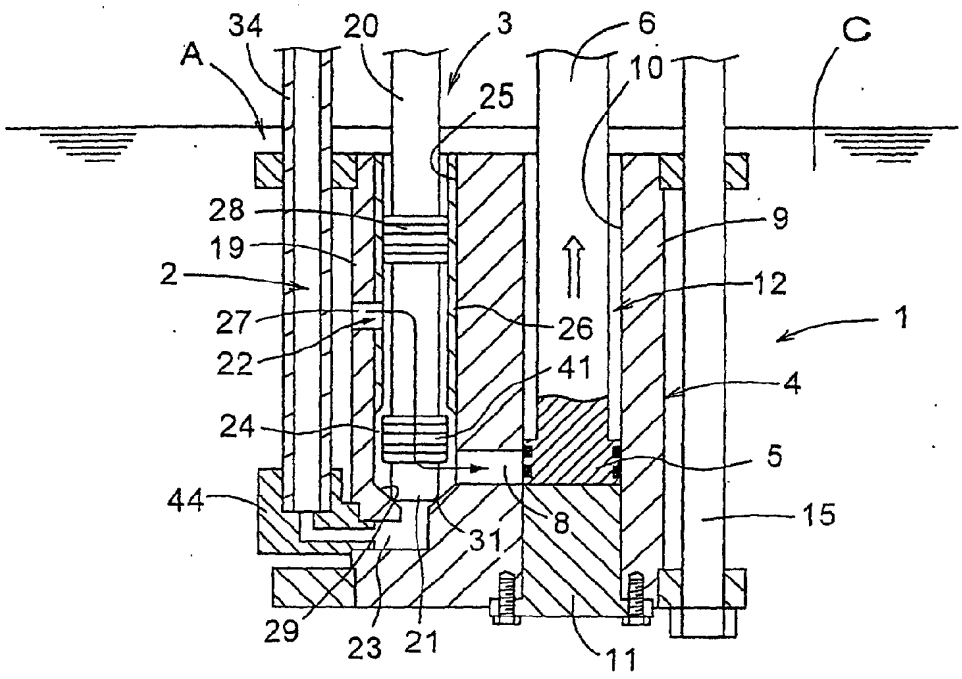


Fig.4

(a)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4
24
5
44
8
15
31
29
23
21
11

(b)

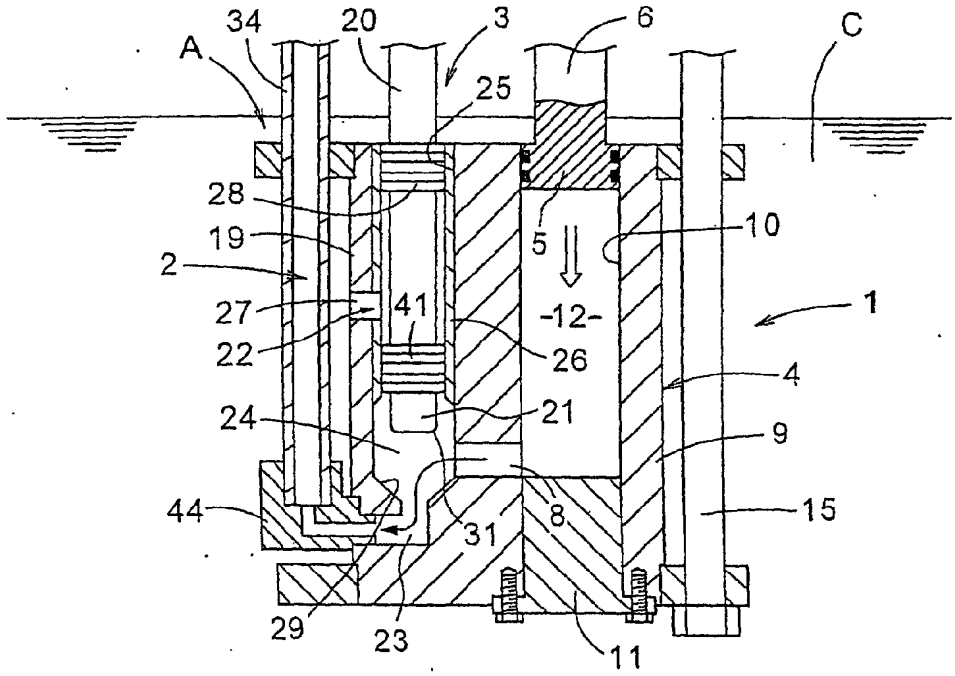
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Fig.5

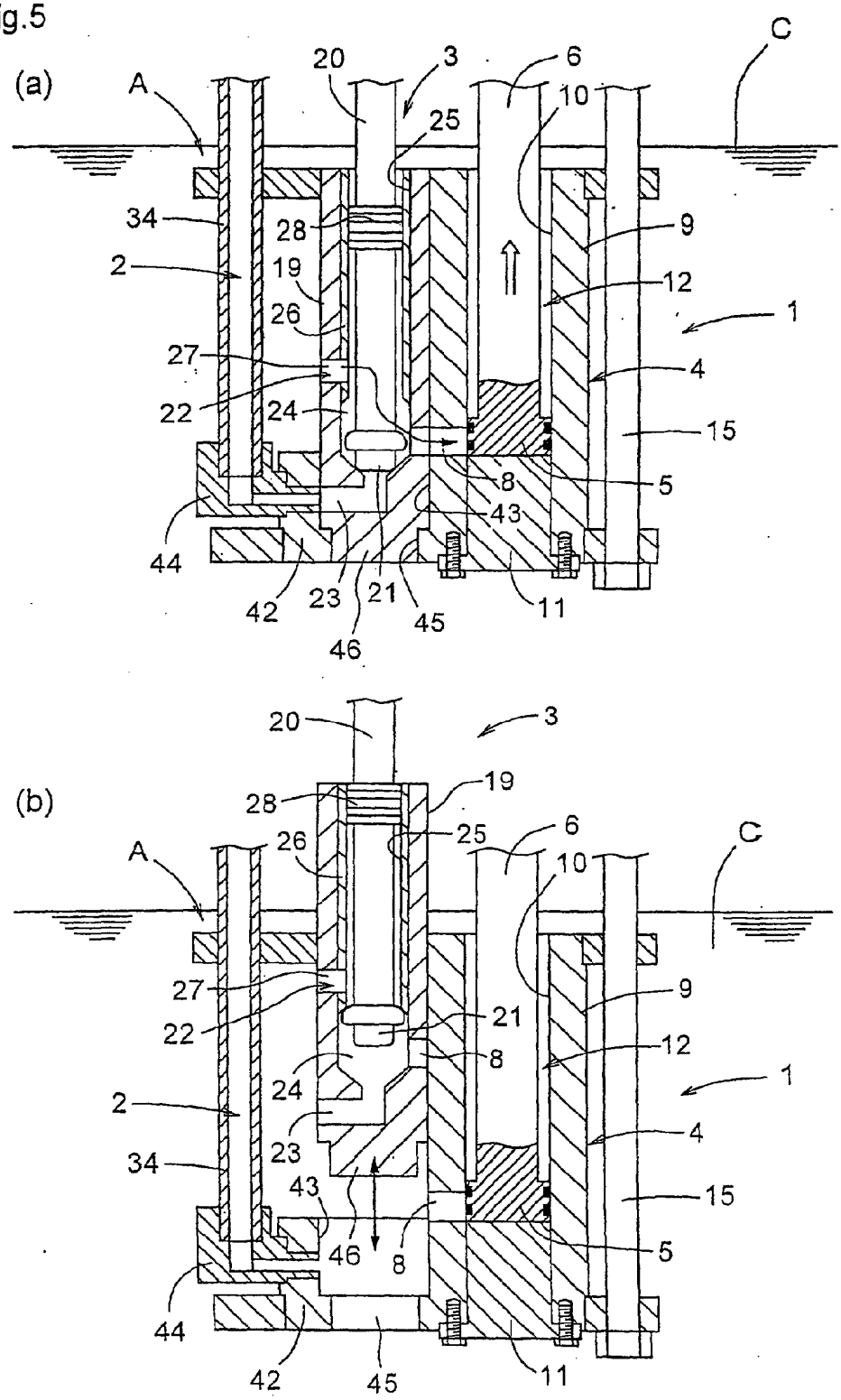
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Fig.6

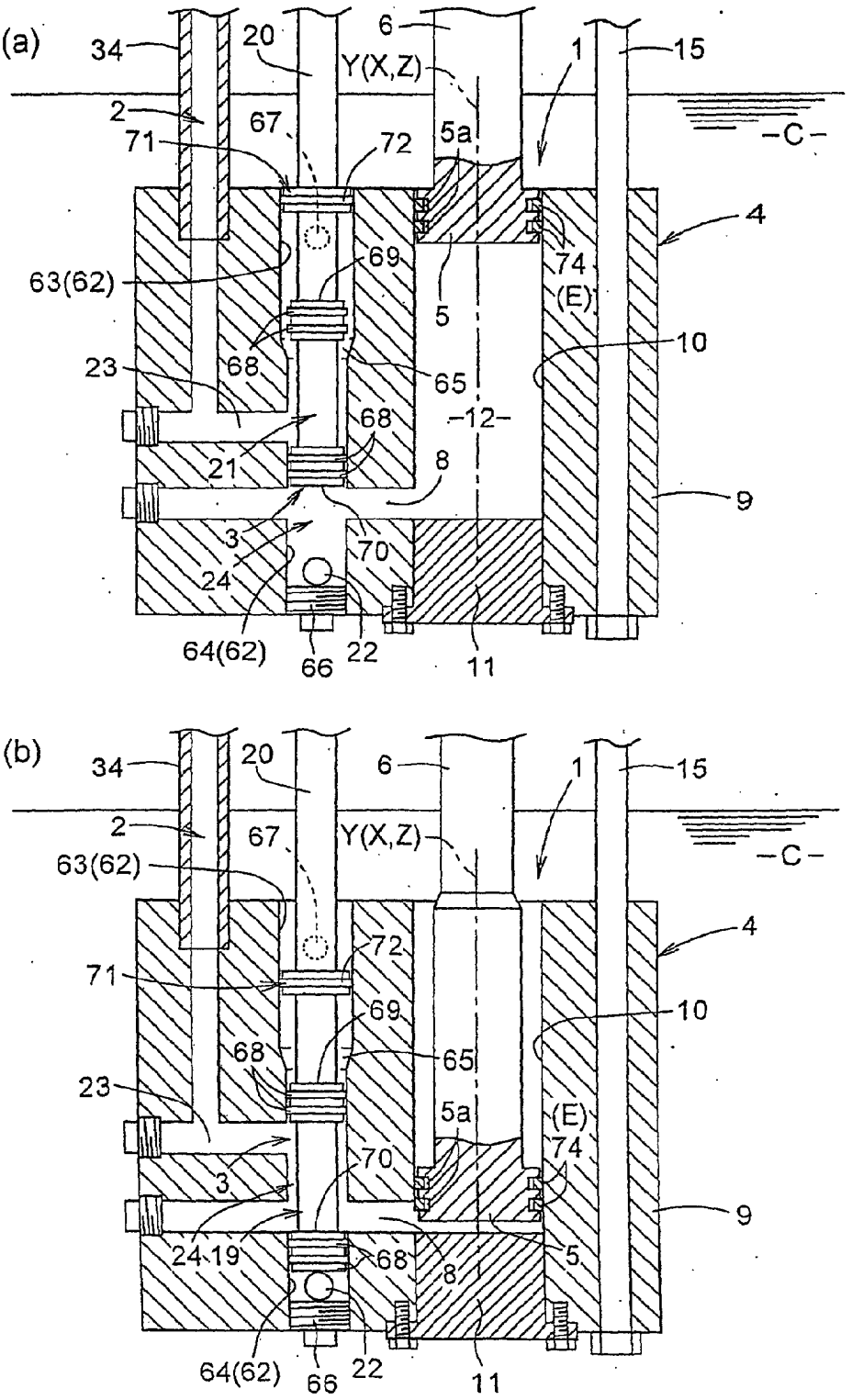
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Fig.7

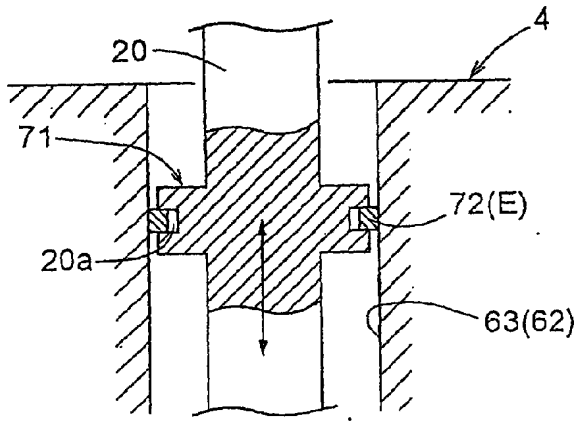


Fig.8

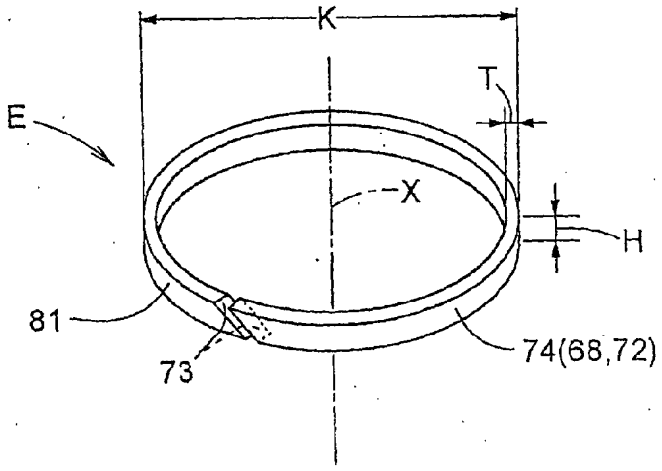


Fig.9

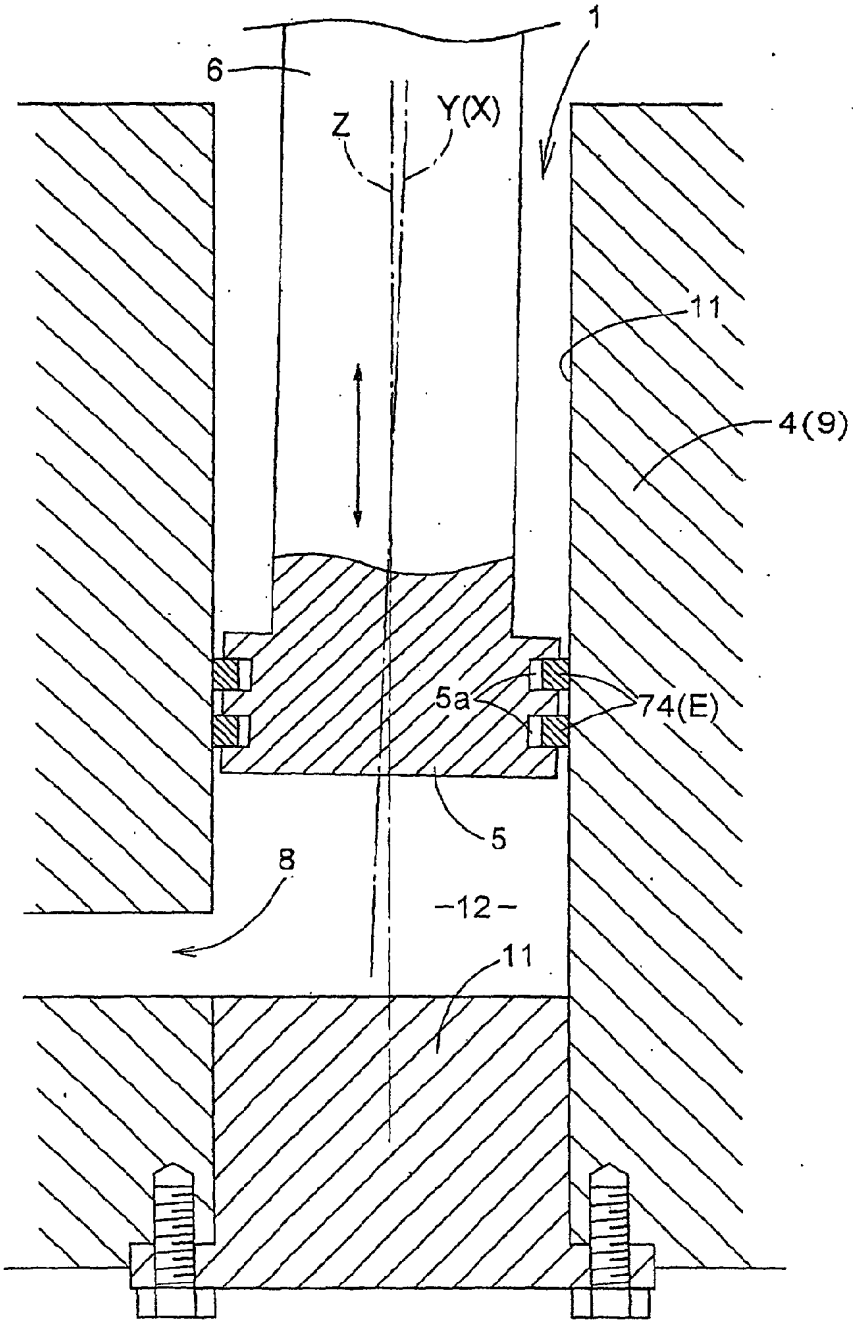


Fig.10

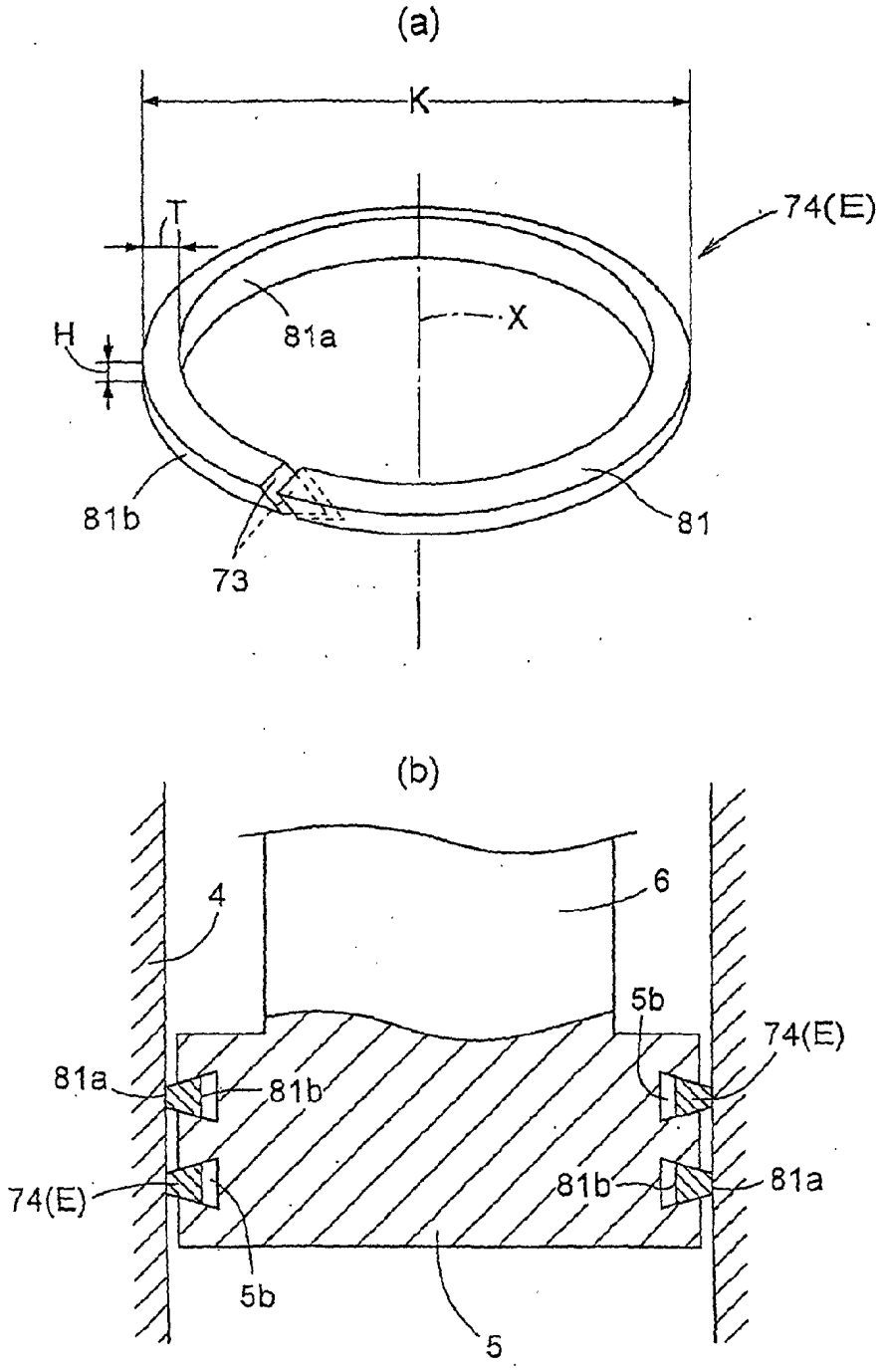


Fig.11

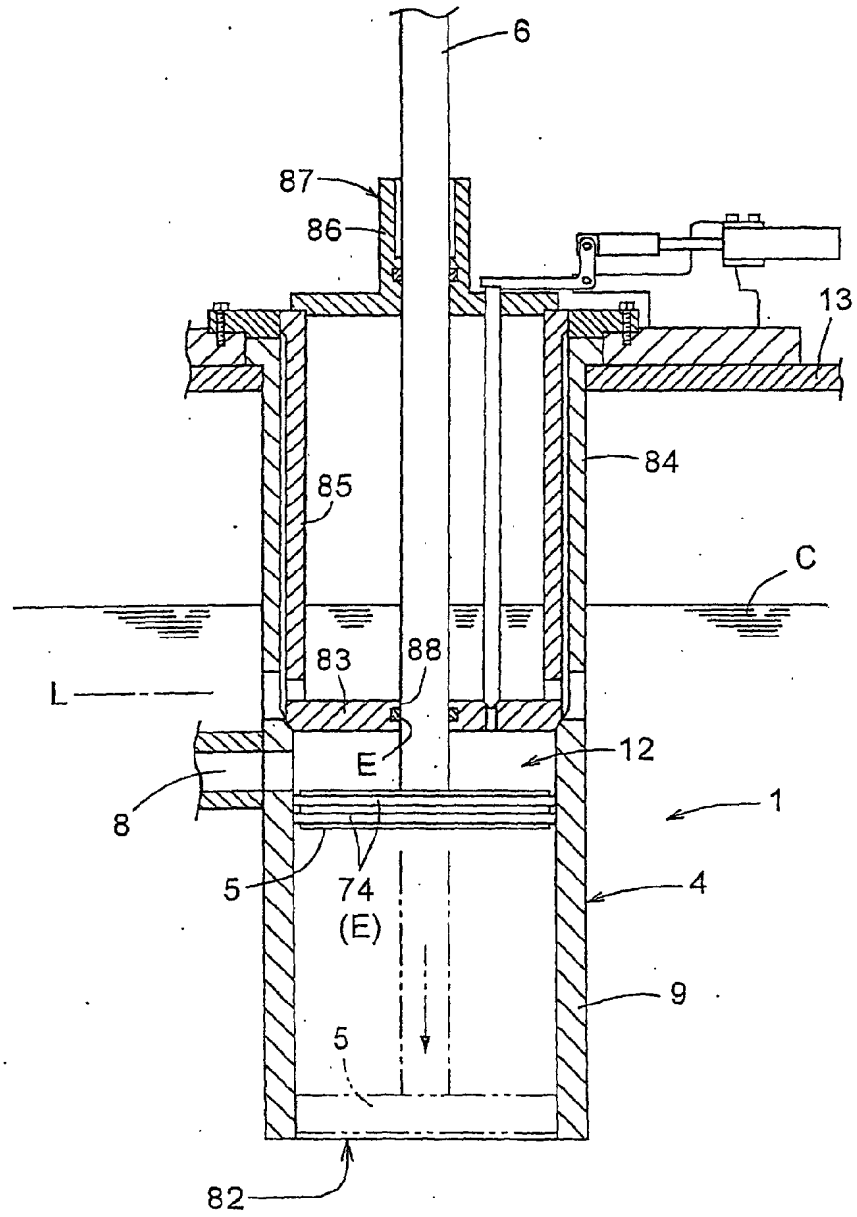


Fig.12

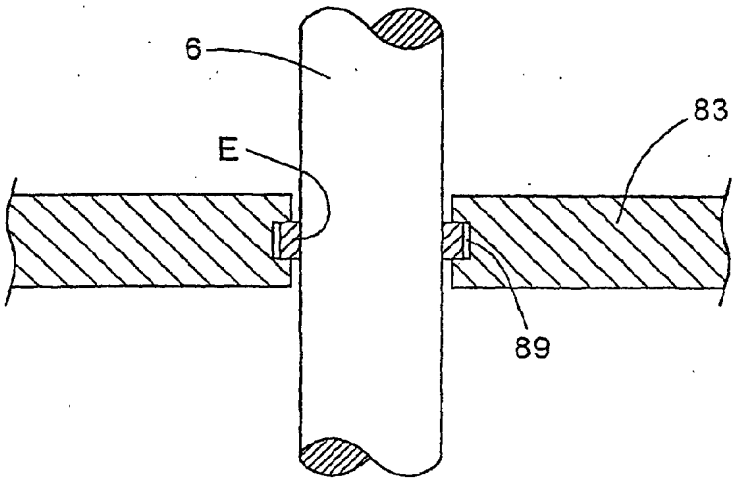


Fig.13

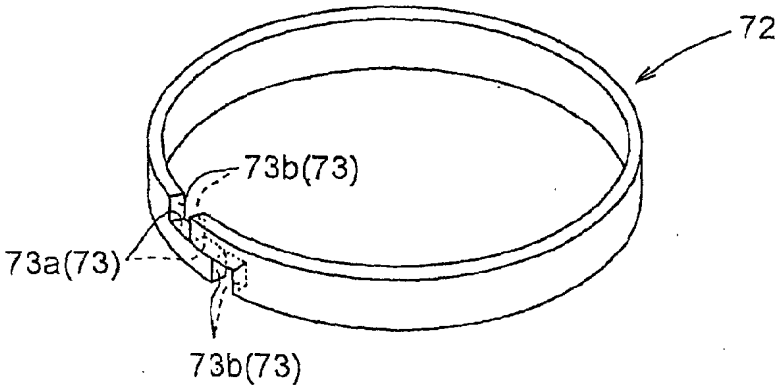
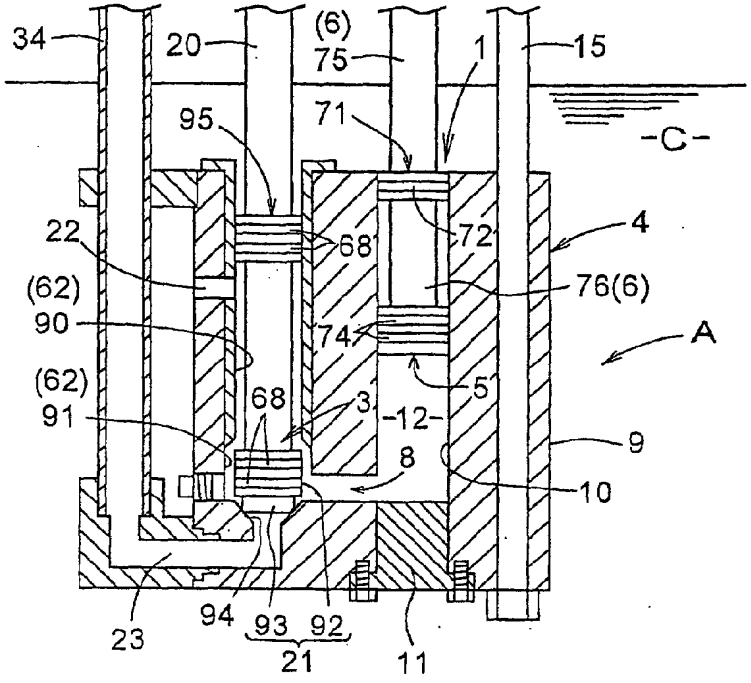


Fig.14

(a)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(b)

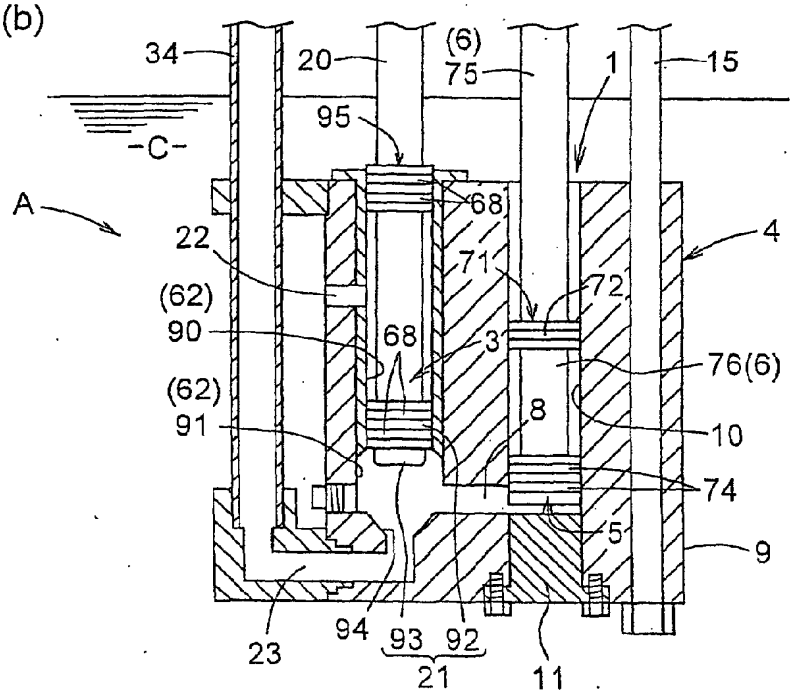
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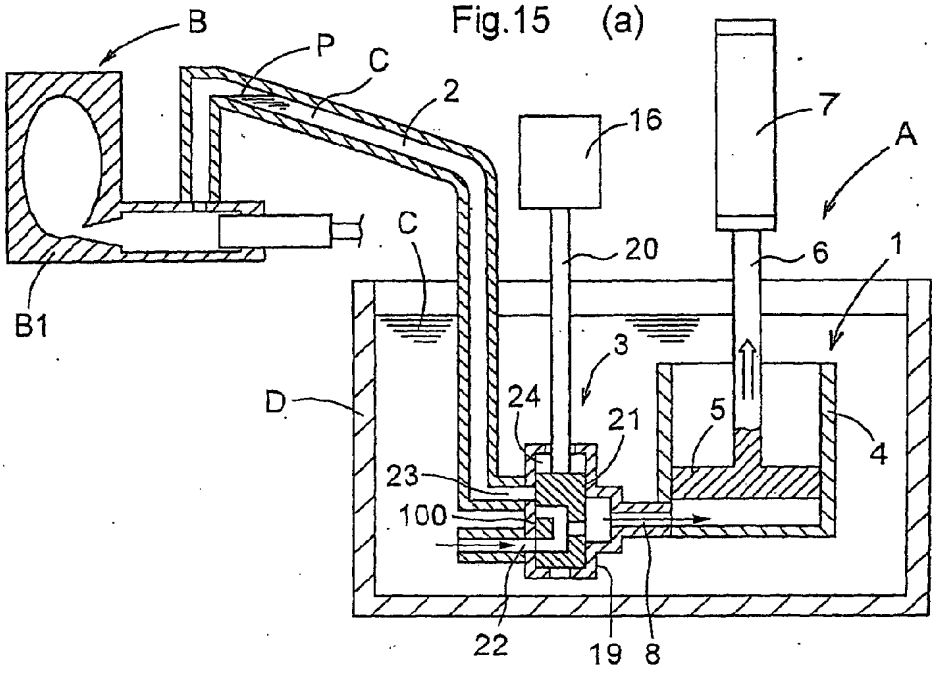
Fig.15 (a)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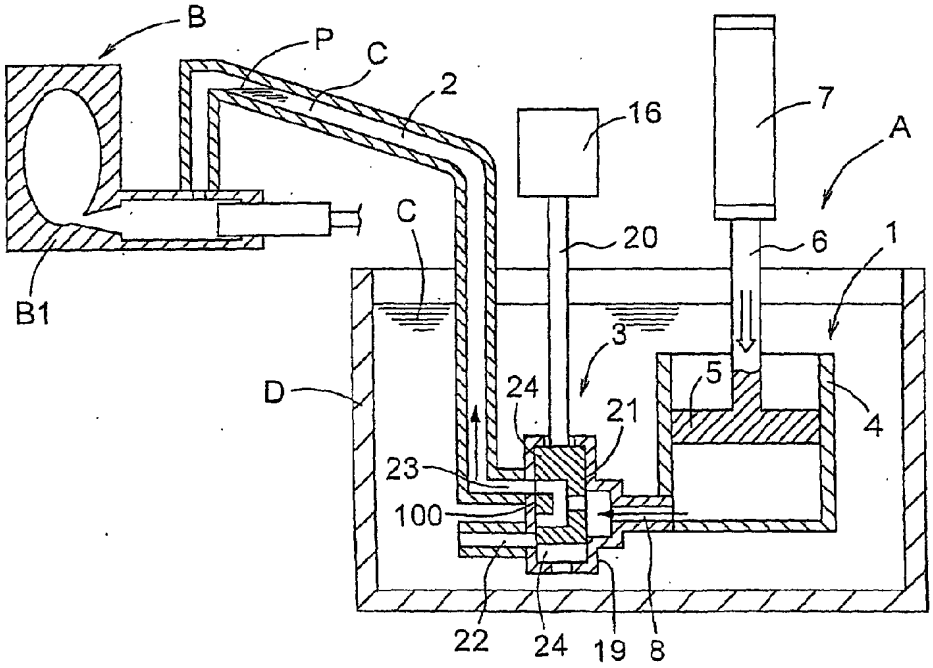
(b)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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP02/05451

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] B22D35/00, B22D17/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] B22D35/00, B22D17/02, B22D17/30, B22D37/00, B22F39/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Toroku Jitsuyo Shinan Koho	1994-2002
Kokai Jitsuyo Shinan Koho	1971-2002	Jitsuyo Shinan Toroku Koho	1996-2002

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DIALOG(WPI/L)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 8-19848 A (Ube Industries, Ltd.), 23 January, 1996 (23.01.96), Claims; Par. Nos. [0006] to [0009]; Figs. 1, 2 (Family: none)	1,2,6,7,9 8 3,4,5,10
X Y A	JP 8-25014 A (Ube Industries, Ltd.), 30 January, 1996 (30.01.96), Claims; Par. Nos. [0006] to [0007]; Figs. 1 to 3 (Family: none)	1,2,6,7,9 8 3,4,5,10
Y	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 14400/1992 (Laid-open No. 65458/1993) (Toshiba Machine Co., Ltd.), 31 August, 1993 (31.08.93), Claims; Par. Nos. [0012] to [0013]; Fig. 2 (Family: none)	8

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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 August, 2002 (06.08.02)	20 August, 2002 (20.08.02)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 1998)